Convention Number

Electrical West

With which is consolidated the Journal of Electricity

A McGRAW-HILL PUBLICATION | May 15, 1929 | FIFTY CENTS PER COPY

WHAT WESTINGHOUSE IS DOING TO MODERNIZE INDUSTRY

FROM OIL WELL TO FILLING STATION WESTINGHOUSE SERVES THE PETROLEUM INDUSTRY

Electricity brings the oil fields to you

When you fill your car at a nearby gasoline station, or order fuel oil for your furnace, you are probably tapping an oil field that's half a continent away. Electrical equipment—plays a big part in the convenient distribution of petr... With electric power, th... The... stations, to man the pumps that hurry the oil along to its destination—six or six hundred miles away. ...modern ...

THE above rotogravure advertisement, appearing in leading newspapers, features the advantages of electrification in a basic industry of the Pacific Coast.

Westinghouse advertising in both the newspapers and the industrial press is designed to extend the applications of electricity to every phase of modern life and industry.

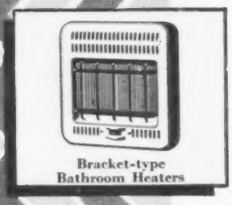
Westinghouse

WESTINGHOUSE ELECTRIC

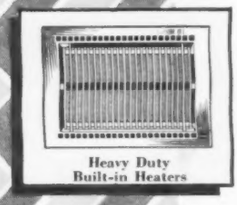
Combination Hotcake and Waffle Iron

Convenience Outlet Portable Heaters

Heavy Duty Portable Heaters


Bracket-type Bathroom Heaters

Built-in Bathroom Heaters


Heavy Duty Built-in Heaters

Reflector Heaters

A busy JUNE ahead on Majestic

Last year one-third of all the Waffle Irons sold at retail on the Pacific Coast were MAJESTICS. A fine tribute to a superior idea—a waffle iron and hot cake griddle in one compact unit at an attractive price.

June, the month of brides and anniversary gift giving, is always a record month for MAJESTIC dealers. Get your share of this attractive business and PROFIT. Our own localized newspaper advertising helps. Place your June 1 delivery orders for

The Nation-Wide Favorite

MAJESTIC

COMBINATION

HOT CAKE and WAFFLE IRON

Here you have a champion among the smaller load-builders for it is put to so many practical uses every day.

The Majestic requires no "breaking in"—no grease—batter cannot overflow—self-contained switch connection. Chromalox-equipped—built to last and give the right heat. Reversible aluminum grids—instantly removable for easy cleaning. Finished in nickel and ebony. Guaranteed trouble proof.

Information and prices on any or all Majestic Products sent on request.

MAJESTIC ELECTRIC APPLIANCE CO., INC.

Executive Office and Factory
590 Folsom St.
San Francisco

Philadelphia — Kansas City

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W. A. CYR, *Associate Editor*
G. R. HENNINGER, *Associate Editor*

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B. H. SNOW, *Northwest Editor*

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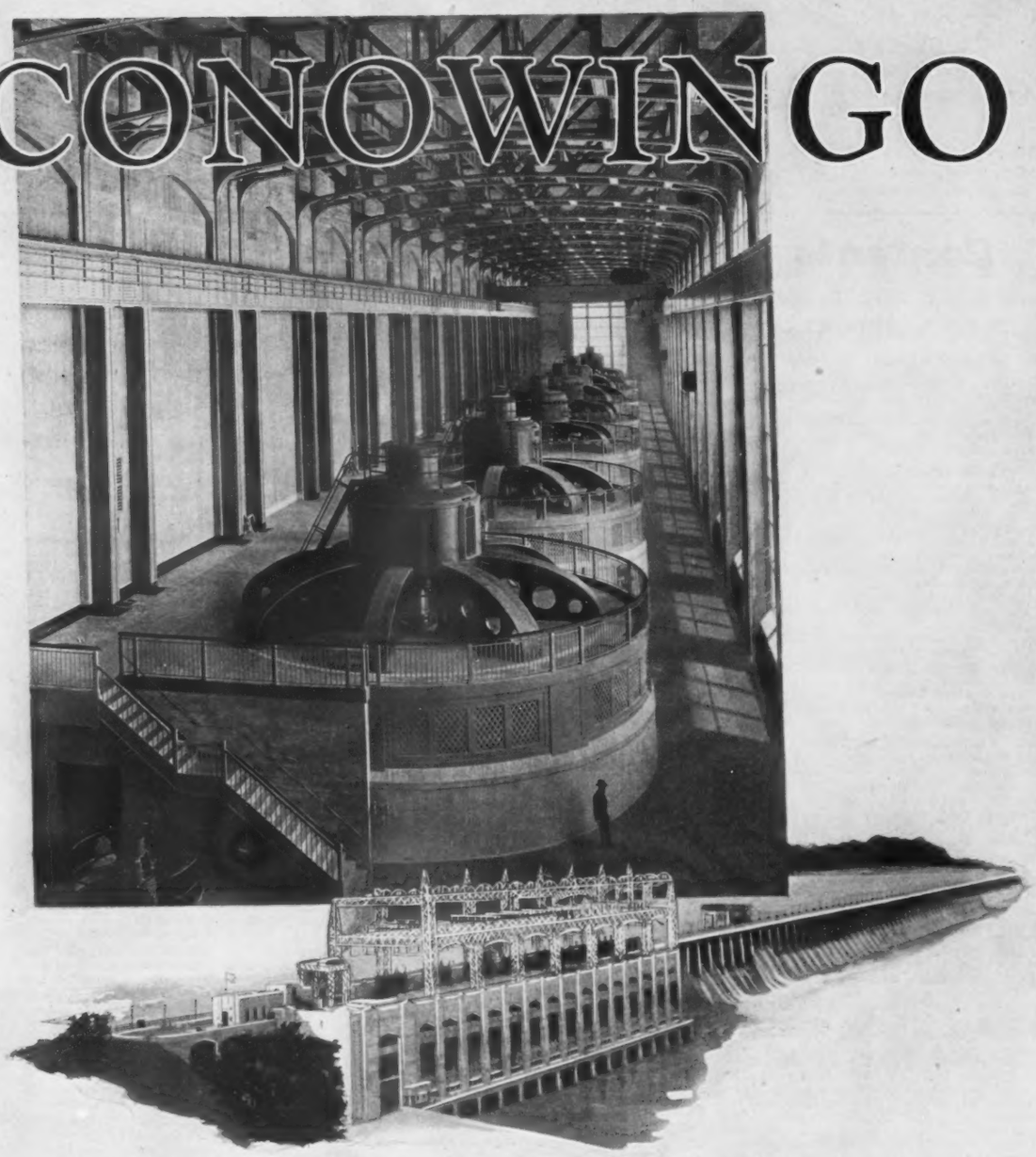

Largest Block of Power, either steam or hydro, ever installed in one operation. Finished six months ahead of schedule.

Stone & Webster, Inc., designers, builders, and consulting engineers

STONE & WEBSTER
INCORPORATED

OPERATE FINANCE BUILD

MAY 31 1929
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Electrical West

With which is consolidated the Journal of Electricity

A McGRAW-HILL PUBLICATION

C. T. HUTCHINSON
Editorial Director

G. C. TENNEY
Managing Editor

Volume 62 | San Francisco, May 15, 1929 | Number 6

A Year's Work

TEN, twenty or more years ago the one-man industrial establishment was predominant. The big boss was the Pooh Bah. He decided everything; he ran everything. This was not so difficult before the day of the transcontinental telephone, the radio, and the air mail. But 1929 is the age of the billion-dollar institution, with its hundreds of district offices, its international distribution, its great corps of specialists, its division of experiment and research.

NOW the executive can no longer know it all. If he understands inter-departmental relationships, and the basic controlling factors that bring about success or failure, to say nothing of human relations, he is earning his five- or six-figure salary. If the chief executive is limited in his knowledge, how, conceivably, can the department head or employee know it all? What chance does he stand ever to become the boss? It is here that the service rendered by the industrial press comes into the picture.

THIS issue of Electrical West is an example of that service. Within its covers is presented a symposium of progress in the Western electrical industry. The findings embodied in the reports are the result of a year's work on the part of more than eight hundred men, members of committees to whom are entrusted the responsibility of study, analysis and research within the many specialized fields concerned. There have been countless committee meetings, and many conclaves in which these reports have been discussed and revised.

AND all of this work, all of this effort on the part of the working members of the Pacific Coast Electrical Association and the Northwest Electric Light and Power Association will be rendered abortive if the rank and file within the industry already think they "know it all."

FOR the man who today emulates the example of the ostrich, and sticks his head in the sand in the delusion that he is hiding his ignorance, there will be no future, and a very insecure present. For the man who has the intelligence to use the experience of these eight hundred men, freely offered for his service in solving his own problems, there is a wealth of knowledge, the self-confidence that it imparts, and the inspiration to do better things. And that is what really counts.

Let's Increase Load Density on Existing Facilities

By P. M. Downing

President, Pacific Coast Electrical Association.

ANOTHER year has passed and we are again on the threshold of the annual convention of the Pacific Coast Electrical Association. In reviewing the accomplishments of our industry during the past year we do so with a feeling of mixed pride and satisfaction in the progress which has been made. The power shortage that existed during and immediately following the war period has been overcome and the supplying companies are now in a position to furnish every demand that may be made upon them. Lines have been extended into new territory to such an extent that electric service is now available in practically every community.

The most important problem confronting the industry at the present time is that of reducing the cost of service to the lowest point possible and of increasing the business. The technical and engineering features having to do with the quality of service have been taken care of very satisfactorily and rapid progress is being made in the way of improving the efficiency of production of electric energy.

P. M. DOWNING

The next important step, looking toward the reduction of costs to the ultimate consumer, is to increase the density of load on existing facilities. This is a commercial problem that is being met by intensive sales campaigns covering wide fields of application. These sales efforts are largely educational and are of value, in fact they are essential, in order that the general public may know of the many new applications and uses that are being made of electric energy, also the advantages, economic and otherwise, that come from a greater and more general use of this wonderful servant of man. That splendid progress is being made along this line is evidenced by the fact that each year's business shows a very substantial and satisfactory increase over that of the previous year.

In bringing about the greater development of our industry the Pacific Coast Electrical Association has played an important part. It has afforded the opportunity for bringing together men from every branch of the industry for the discussion and study of the various problems that are common to all. The work that is being done by the various committees of the association is of substantial value to the industry. The so-called conclaves that are held every three months by the commercial, engineering and other sections should not be looked upon as vacations or junketing trips. On the contrary, those who attend make them occasions for the exchange of ideas and the serious discussion of problems of importance to the industry. The time and expense of this work is well worth while and their efforts should be encouraged.

The annual conventions of the association serve broader and more useful purposes than do the conclaves in that they afford opportunities for bringing together not only those who have to do with the practical problems of the industry but also the executives and others having to do with the administration of the business affairs of the industry. The contacts made at these meetings, whether social or in connection with the more serious matters that come up, are of great value not only to the individuals directly concerned but they are also of great value to the different interests they represent.

Accounting Section[1]

Joint Pole Records*

This record may be said to represent a continuous history of poles, the additions and removals accurately kept for retirement purposes so that an up-to-date physical inventory of this property is practically complete at all times. Other outstanding features are:

1. Centralizing of the detail in connection with joint pole use in the distribution department.

2. The maintaining of a complete historical record in the utilities' offices as well as the office of the joint pole committee.

3. Map records, pole card records, and job blue print records absolutely essential to avoid repetition of payments.

ON OCT. 10, 1906 an agreement was entered into by the several utilities in and about Los Angeles for the joint use of poles and the elimination of extra poles from streets. This agreement has been in effect since that date with amendments made as has been found necessary. The original Joint Pole Committee was composed of the following members:

Home Telephone Company
Sunset Telephone Company
Pacific Electric Railway Company
Los Angeles Railway
Pacific Light & Power Company
Southern California Edison Company
Los Angeles Gas and Electric Corporation.

Advantages

Joint use of poles where possible has many advantages as has been proved conclusively by the Los Angeles practice. It has not only worked to the economical advantage of the companies, but has also been the means of keeping pole lines at a minimum in the streets and highways. This has also worked to the advantage of the utilities because it has deferred legislation requiring lines to be placed underground in the close-in districts. It has also made possible the use of easements in back property lines for the use of power and communication lines, thereby clearing the streets of pole lines which are always objectionable to resident districts. The Los Angeles Gas and Electric Corporation with approximately 53,000 poles in its system is in joint ownership on nearly 38,000 poles which gives one an idea of the extensive use made of joint pole privileges. There are over 200,000 poles jointly used in the district served by the companies involved in the agreement, and estimated on a basis of two and one-half utilities for each joint pole there would be required 300,000 more poles than are now being used if there was no joint use in this district.

Division of Operating Expense

Since the original Joint Pole Committee was formed other companies desiring to benefit by this practice joined the committee as limited members until today we find the following companies enjoying the privileges of joint ownership in poles:

Pacific Electric Railway Company
Los Angeles Railway Corporation
Southern California Edison Company
Los Angeles Gas and Electric Corporation
Pacific Telephone & Telegraph Company
Southern California Telephone Company
City of Los Angeles
City of Glendale
Santa Monica Bay Telephone Company
Associated Telephone Company
City of Pasadena

as full members, and

City of Colton
Atchison, Topeka & Santa Fe Railway Company
Los Angeles & Salt Lake Railroad Company
The Southern Sierras Power Company
Ontario Power Company
U. S. Long Distance Telephone Company
Redondo Home Telephone Company
City of Riverside
Glendale-Montrose Railway
Postal Telegraph-Cable Company
Southern Pacific Company
Western Union Telegraph Company
City of Burbank
Whittier Home Telephone Company

as limited members. The full members pay their percentage of the committee expenses in proportion to their equity in recorded combinations on a share basis. The limited members pay a percentage of the value of the transactions consummated by them.

Procedure

The Joint Pole Committee is a clearing house for all joint pole transactions and an actual field agreement between the representatives of all the companies involved is essential for the issuance of a joint pole authorization. The originating company, or preferably the company who is to do the work, draws up the field agreement, obtains the signatures of all parties involved, assigns an authorization number and gives each interested company a copy of said agreement. In a recent questionnaire regarding the routine of joint pole authorizations within a utility's organization it is found that most companies are operating under practically identical methods in that the distribution departments handle all details in connection with joint poles tying in the joint pole authorization with their distribution jobs. The field agreement forms the basis for pole accounting and is kept in the originating company's office until the work is completed, at which time all the necessary recording data are copied on a pink form and forwarded to our clearing house, the Joint Pole Committee, who in turn checks their existing records forwarding each company interested a copy of the completed authorization on a white form which gives a check against the actual field agreement and constitutes notice that the originating company has completed its work, has sent in the authorization to the committee for billing and fifteen days are allowed to all for checking or objection. If objection is registered from any party to the agreement the entire matter is referred back to the interested parties for a new agreement acceptable to all. If no objection is received pole cards

[1] Executive committee—H. T. Terry, chairman. C. P. Staal, vice-chairman. J. A. Cannon, A. B. Carpenter, H. P. Dayton, P. R. Ferguson, H. W. Johnson, H. Painter, L. A. Reynolds, E. N. Simmons.

* Report of joint pole records committee, Accounting Section. Prepared by 1927-28 committee, but not submitted for publication until April 1, 1929. William Haeckel, Los Angeles Gas & Electric Corporation, chairman; P. R. Ferguson, The Southern Sierras Power Company; Archie Mieklejohn, Southern California Edison Company; A. S. Walthall, San Joaquin Light & Power Corporation.

FORM 10 — S

16279-G
POLE NUMBER — LOCATION Wesley Ave. W.S. 33' S. of 41st Dr. Los Angeles

LENGTH & SPECIES	SET NEW	SET 2nd HAND	CONDITION
40' c (Job 10369)	1918		PST

CIRCUITS AND RECORD OF JOINT INTERESTS--CONTRACT OF OCT. 10TH, 1906

P.E.RY. CO. R	L.A.RY. CORP. C	S.C.E. CO. E	L.A.G.&E. CORP. G	T.P.T.&T. CO. T	S.C.T. CO. H	CITY OF L.A. M	TRANSACTION NUMBER	BILL OF SALE DATE
			L 1/2		C 1/2		1	6-29-18
			L 1/3		C 1/3	L 1/3	2	1-31-28
			$7.94					
ABANDON 1/2 in 25 ft. $4.38 Acct. C.R.C.346 Orig.Bill of Sale 8/31/1915								

16279-G-1: L. A. G. & E. Corp. bill S.C.T.Co. for $7.83: Auth 3160 ACCT. C.R.C. 346
SALES TICKET NO. 7842

16279-G-2: L. A. G. & E. Corp. and S.C.T.Co. each bill City of Los Angeles for $3.97: Auth. M-4580, Part 6 ACCT. C.R.C. 346
SALES TICKET NO. 68122

Record correct to January 10, 1928
ACCOUNT C.R.C. 346

FORM 10 — S

41935-G
POLE NUMBER — LOCATION E. 4th St. S. W. Cor of Anderson St. los Angeles

LENGTH & SPECIES	SET NEW	SET 2nd HAND	CONDITION
70'c (Job 17826)	1926		PT

CIRCUITS AND RECORD OF JOINT INTERESTS--CONTRACT OF OCT. 10TH 1906

P.E.RY. CO. R	L.A.RY. CORP. C	S.C.E. CO. E	L.A.G.&E. CORP. G	T.P.T.&T. CO. T	S.C.T. CO. H	CITY OF L.A. M	CITY OF GLENDALE A	S.M.S.T. CO. H	DATE
HC 1/5 V	TC 1/5		HL 2/5 V			L 1/5			9-30-27
			$32.64						

41935-G-1: L. A. G. & Corp. bill P. E. Ry. Co. for $16.32: No charge to L. A. Ry. Corp. and City of Los Angeles: Auth. G-346, Part 1 (Val.$16.32) (Val.$16.32) ACCT. CRC 346

R Sales Ticket #65646 $16.32
M Sales Ticket 65642 No Charge
C Sales Ticket 65644 No Charge

Note Pending:
Auth. No. E-2 - 2159
E to buy interest.

Record correct to September 1,1927.
ACCOUNT C.R.C. 346

FORM 10 — O

10120-G
POLE NUMBER — LOCATION Commercial St. N.S. 220' W. of Hewitt St. Los Angeles

LENGTH & SPECIES	SET NEW	SET 2nd HAND	CONDITION
45' c	1907		P

CIRCUITS AND RECORD OF JOINT INTERESTS--CONTRACT OF OCT. 10TH. 1906

P.E.RY. CO. R	L.A.RY. CORP. C	S.C.E. CO. E	L.A.G.&E. CORP. G	T.P.T.&T. CO. T	S.C.T. CO. H	CITY OF L.A. M	TRANSACTION NUMBER	BILL OF SALE DATE
			L 1/2			L 1/2		5-31-20
			L 1/3		C 1/3	L 1/3		12-31-25
			L 1/2		C 1/2			2-29-28
			$3.00					

10120-G-1: L. A. G. & E. Corp. bill S.C.E.Co. for $2.97: E-2356-20 ACCT. Dist.Poles & Fix. Prior to 1913 SALES TICKET NO. 747

10120-G-2: L. A. G. & E. Corp. and City of Los Angeles each bill S.C.T.Co. for $1.05: H-2995 ACCT. C.R.C. 346 SALES TICKET NO. 56292

10120-G-3: City of Los Angeles relinquished interest, 7-15-27: Auth. M-4525, Part 1 (WRITE OUT 1/3 interest $2.10 ACCT. C.R.C. 346) (ACQUIRE 1/2 interest 3.00 ACCT. C.R.C. 346)

Record correct to February 15, 1928.
ACCOUNT C.R.C. 346

Fig. 1. Samples of joint pole records cards.

(See Fig. 1) are made from the recording data as shown on the pink form, a set of cards sent to each company involved with ten days allowed for corrections; if none received they are considered correct and bills of sale issued accordingly.

Method of Billing

Bills of sale are issued each month by the Joint Pole Committee for pole interests, salvage on poles retired, transfer costs or other fixel charges agreed upon in the authorization. The cards having by this time been checked as to price, size and location, are in turn checked against the bills of sale. Joint Pole Committee schedule of pole prices is used for the year in which the transaction was consummated which takes into consideration the kind, size and age of pole.

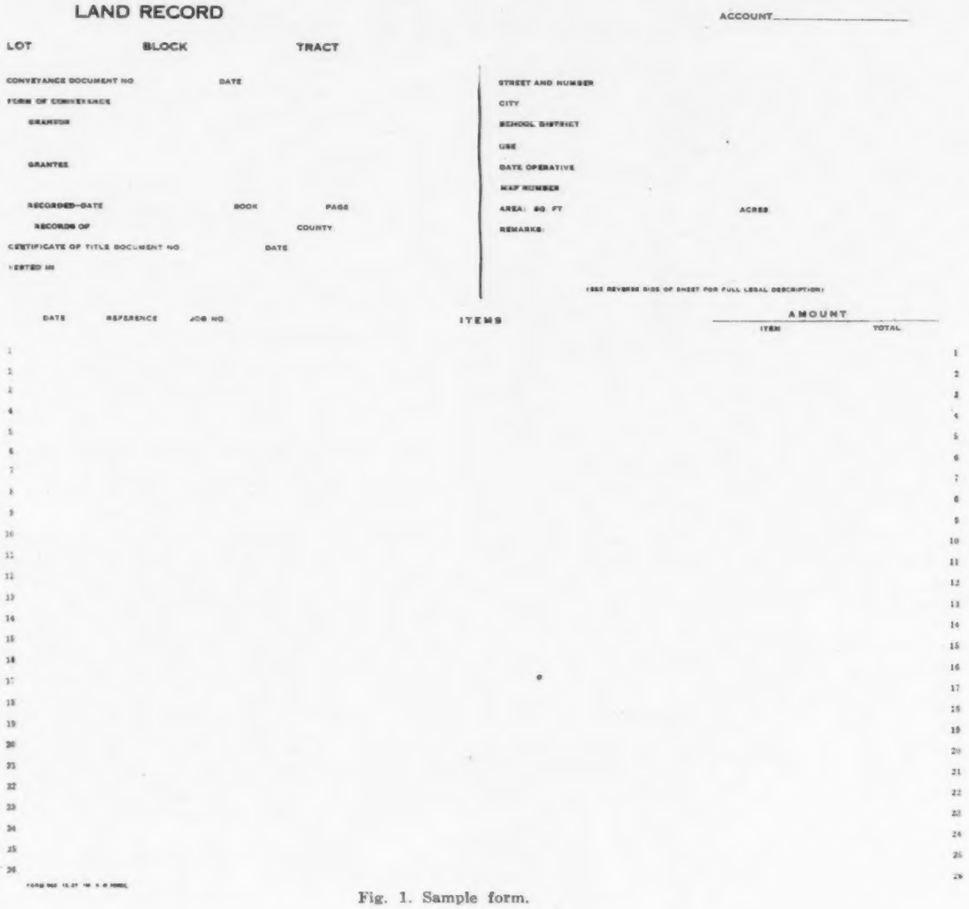
Accounting

All utilities in this district operate under the California Railroad Commission classification of accounts. In accounting for joint poles it is necessary that the proportional interest be recorded as well as the value. The Los Angeles Gas and Electric Corporation in order to maintain a complete historical record of poles has all the accounting shown directly on the pole card itself. The procedure followed in buying interest in foreign poles is to acquire the interest and money value into the capital account affected which is "Distribution Poles, Towers and Fixtures C.R.C. 346." In the matter of sales the procedure is to retire at cost to the installing company, either the whole pole, if the company is the original owner, or the proportional interest owned at the time of sale and acquire the remaining interest at the prevailing joint pole schedule of prices into "Distribution Poles, Towers and Fixtures C.R.C. 346." The auditor sends his representative to the distribution department where the book entries are made directly from the pole card record, the book being checked against the itemized bills of sale which have been forwarded to the auditor with a sales ticket or certificate. Map records are kept of all poles set or purchased or on which the company's lines have been attached. At time of pole appearing on a bill of sale as combination the poles on the maps are marked with a small yellow "c" denoting that pole is jointly owned and has been paid for or part interest sold. With the map record, pole card record and job blue print record all chance of paying for the same pole twice has been eliminated.

Real Estate and Tax Records*

EXPERIENCE has taught us that the records of yesterday are inadequate to meet present day requirements. Rate engineers, valuation engineers, statisticians, regulatory bodies and general managers are

* Report of committee on real estate and tax records, Accounting Section. Prepared during 1927-28, but not submitted for publication until April 1, 1929. C. D. Cushman, chairman. A. B. Carpenter, P. R. Ferguson, C. N. Rudkin.


LAND RECORD

LOT BLOCK TRACT

CONVEYANCE DOCUMENT NO. DATE

FORM OF CONVEYANCE

GRANTOR

GRANTEE

RECORDED—DATE BOOK PAGE

RECORDS OF COUNTY

CERTIFICATE OF TITLE DOCUMENT NO. DATE

VESTED IN

ACCOUNT

STREET AND NUMBER

CITY

SCHOOL DISTRICT

USE

DATE OPERATIVE

MAP NUMBER

AREA: SQ. FT. ACRES

REMARKS:

(SEE REVERSE SIDE OF SHEET FOR FULL LEGAL DESCRIPTION)

DATE REFERENCE JOB NO. ITEMS AMOUNT ITEM TOTAL

Fig. 1. Sample form.

now asking questions and requiring information about real estate and other capital accounts, which would necessitate a long tedious search, if capital ledgers are not in such form as to permit of ready analysis.

A few years ago, before the utilities came under state regulation, a single real estate or land account in the general ledger seemed to suffice for all needs. In 1913 with the establishing of a uniform classification of accounts, the single account was broken up into two accounts, namely, "Electric Land" and "General Land"; and in 1924 the classification was revised to contain seven subdivisions consisting of: "Steam Power Plant Land," "Hydraulic Power Plant Land," "Gas Power Plant Land," "Transmission Land," "Distribution Land," "General Office Land" and "Other General Land."

The larger utilities in California have found it necessary, in recent years, to purchase many new parcels of land to provide for increased plant facilities. Each lot or parcel purchased necessarily resulted in several, and sometimes many, entries to the particular subordinate land account to which it was applicable. These entries were generally spread over a considerable length of time. First there might be the usual deposit to bind the bargain, later the balance of purchase price would be paid into escrow and at the close of the escrow miscellaneous items would require still further payments. Assessments for street improvements and other items were almost sure to appear at irregular intervals. Thus the entries for a particular parcel or lot become interwoven with similar entries for other parcels. When the cost of a certain lot was desired it was necessary to pick off the various items. This was unsatisfactory not only on account of the time required, but also on account of the lack of proof of accuracy.

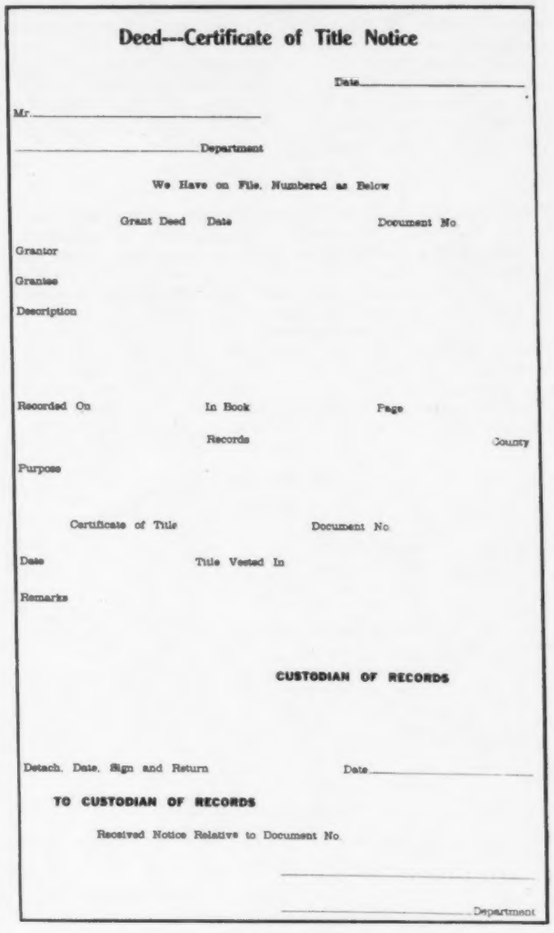
Assuming that the average utility, especially the one owning a considerable amount of land, finds it necessary, quite often, to know costs on single units, the committee suggests an auxiliary real estate record which will furnish this information.

The proposed method is to establish an auxiliary ledger with a separate sheet for each parcel or lot. Here a question arises upon which the committee members are not in entire agreement. In a case where two or more contiguous lots are purchased for a lump amount, some recommend entering all on one sheet and later establishing separate costs should occasion require. It is contended that in some cases it might never be necessary to effect a segregation. This plan, however, would impair the completeness of the analysis and result in delay when data on such lots was wanted. Each entry on the individual sheets of the proposed ledger would consist of date, reference, explanation and amount. The sheets would be arranged in sections, each section comprising all the parcels or lots in one land account. By bringing together the totals of the sheets in a division or section, a ready tie-up is secured with the controlling account in the "General Ledger" or "Capital Accounts Ledger." In addition to the above entries, the following important information should appear on each ledger sheet:

1. Form of conveyance.
2. Grantor.
3. Grantee.
4. Recorded—date, book, page, records of county.
5. Deed document number, date.
6. Certificate of title document number, date.
7. Account number.
8. Job or work order number.
9. Lot number, block number, tract or addition.
10. Street and number, city or school district.
11. Use.
12. Operative or non-operative.
13. Full legal description.
14. Map number.
15. Area in sq.ft. and acres.

Maps are a necessary part of the real estate record and it is recommended that they be kept in a separate book filed by cities or political subdivisions. A piece of property might sometimes be more easily located by referring to the map book, where a folio reference would tell the exact location in the ledger. Or if the ledger was first consulted, the map number appearing thereon would enable ready finding of the map.

Deeds and certificates of title or equivalent documents are an important function in the proposed plan. Much of the miscellaneous data contined in the ledger, as set forth in a previous paragraph, must necessarily



Deed---Certificate of Title Notice

Date_____

Mr._____

_____ Department

We Have on File, Numbered as Below

Grant Deed Date Document No.

Grantor

Grantee

Description

Recorded On In Book Page

Records County

Purpose

Certificate of Title Document No.

Date Title Vested In

Remarks

CUSTODIAN OF RECORDS

Detach, Date, Sign and Return Date_____

TO CUSTODIAN OF RECORDS

Received Notice Relative to Document No.

_____

_____ Department

Fig. 2. Sample form.

be taken from these documents. This may be accomplished either by sending them to the accounting department where the required information could be transcribed to the ledger sheet and proper notation made on the document before returning it to the custodian, or if conditions were such that a risk of losing the document was involved, then the information could be forwarded on a form prepared for the purpose. In either event the system should be such that every document on file would bear evidence that a ledger sheet or sheets had been made for the property described thereon. Also each ledger sheet should indicate the existence of a document for the property in question. We thereby establish, through the proposed record, a tie between the "General Ledger" and the document files.

The active portion of the committee is unanimous in the opinion that the tax record should be separate and apart from the real estate record, as it serves a dif-

ferent purpose and in most cases is in a different department. Tax records pertaining to real estate alone would, however, be closely related to the proposed real estate record. Both would contain similar descriptive data and a comparison of the two records would serve as a valuable aid to the Tax Agent by assisting him to avoid overlooking any taxable real estate. Tax records in their broadest sense cover considerable scope and concern much other than real estate. In most cases land tax is our smallest tax. Heading the list would be state tax based on gross revenue and following would be federal tax based on profits and lastly city and county taxes on real estate, improvements, personal property, plants and franchises, such latter mentioned taxes being levied for purposes of flood control, fire districts, sanitation districts and the like. The supporting data for these records are generally to be found in several different files. This condition necessitates reference to several different places to secure desired information.

There would also properly be included in tax records the forms for estimates, accruals and prorates. It would seem highly desirable that a tax record or ledger be designed that would bring together or centralize these various kinds of tax data. The committee, however, having first decided that real estate records were separate from tax records, spent most of its available time in the study of the former and is, therefore, not in position to render full and complete report on the latter, but feels that the subject is of sufficient importance for further study and consideration, and recommends that it be assigned to a committee at some future date.

Accompanying this report are illustrations showing two sample forms, one of a land record sheet, the other a form used to transmit data concerning deeds, etc. It is not expected that they would be entirely suitable without certain alterations for the needs of all utilities. Nevertheless, they will serve to demonstrate some of the text matter which has preceded.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

Commercial Section[1]

LIGHTING BUREAU REPORTS[2]

THE LIGHTING Bureau this year has endeavored to accomplish certain specific things that would be of mutual benefit to the entire electrical industry.

In view of the fact that this year, 1929, represents the fiftieth anniversary of the invention of the electric incandescent lamp by Thomas A. Edison, the Lighting Bureau has made capital of this opportunity to gain greater recognition for the whole lighting industry.

The work carried on by the individual committees has been of a basic and constructive nature and is certainly worthy of careful consideration.

Bureau Activities

Studies and investigations were carried on this year through the following six subcommittees:

Domestic lighting committee, Frank Bevan chairman. Industrial lighting committee, J. E. Hammond, chairman. Outdoor lighting committee, L. A. Gates, chairman. Airport and airways lighting committee, W. P. Bear, chairman. Commercial lighting committee, Victor W. Hartley, chairman. Educational lighting committee, Clark Baker, Sr., chairman.

Educational

The educational committee this year has continued its work of putting on talks and demonstrations before business men's luncheon clubs, women's clubs, parent-teachers' groups and educational institutions. This committee talked to 40 clubs and educational institutions, a total of 7,600 people.

These talks and demonstrations were of such a nature that would appeal to the group addressed. Talks to merchants were along the lines of better and modern merchandising. The conservation of eyesight and the elimination of glare and gloom were brought before those groups interested in home lighting.

Commercial

The commercial lighting committee have been working on a program to promote minimum standards for adequate electrical installations in commercial structures.

This set of specifications has been carefully gone over by several electrical engineers, city electrical inspectors, illuminating engineers and others interested in the promotion of these specifications. These people have had a background of experience qualifying them to comment competently on them. This study has been just about completed and the specifications will soon be ready to go to print.

This set of specifications, as a companion piece to the present Red Seal activities, has been accepted by the California Electrical Bureau and they will lend their support to the active promotion of these standards over the entire state.

Other reports are presented on the following pages.

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[1] Executive committee—J. F. Pollard, chairman. G. T. Bigelow, vice-chairman. George Baley, R. L. Cardiff, W. E. Carlson, A. M. Frost, C. J. Geisbush, W. C. McWhinney, P. P. Pine, H. C. Rice, W. C. Schafer, G. C. Tenney, F. C. Todt, R. W. Turnbull, J. W. Wrenn.

[2] **W. E. Carlson,** Edison Lamp Works, chairman. **Frank Bevan,** Pacific Gas and Electric Company, vice-chairman. **Benjamin Electric Manufacturing Company:** C. O. Martin. **Coast Counties Gas and Electric Company:** A. E. Strong. **Central Arizona Light & Power Company:** J. H. Wagner, J. W. Wagner. **California Electrical Bureau:** V. W. Hartley. **Curtis Lighting, Inc.:** R. D. Meyers. **Edison Lamp Works:** E. P. Markee, L. G. Gianini, R. V. Ludlum, L. A. Gates. **Electrical Products Corporation:** J. E. Tucker. **General Electric Company:** R. V. Ludlum, E. P. Markee, K. M. Coch. **Graybar Electric Company:** A. R. Fryklund. **Great Western Power Company of California:** M. C. Pfyl, W. J. Walsh. **Edwin F. Guth Company:** L. A. Hobbs. **Holophane Glass Company:** F. A. Hansen. **Illinois Electric Company:** D. C. Pence. **Los Angeles Gas & Electric Corporation:** C. L. Simonds. **Los Angeles Bureau of Power & Light:** F. D. McKinstry. **National Lamp Works:** Clark Baker, Sr. **Pacific Gas and Electric Company:** W. S. Hanbridge, Frank Bevan, W. P. Bear, H. H. Robinson. **Pacific States Electric Company:** Frank VanGilluwe, E. W. Garcia. F. B. Nightingale, F. E. Carey, J. O. Presbrey. **Reiman Wholesale Electric Company:** S. W. Mesick. **San Diego Consolidated Gas & Electric Company:** G. H. P. Dellmann. **San Joaquin Light & Power Corporation:** J. E. Hammond. **Sierra Pacific Power Company:** O. S. Clifford. **Southern California Edison Company:** W. P. Graef, C. E. Houston, W. G. Blossom, R. A. Gulick, R. R. Walbridge, P. J. Denninger. **Westinghouse Electric & Manufacturing Company:** F. A. Lavigne. **Westinghouse Lamp Company:** R. W. Buckles.

Outdoor Lighting Survey*

A QUESTIONNAIRE has been sent out to all jobbers and dealers to determine the results of the Christmas lighting activity for the past season. Data on amount of lamps, sockets, wire and the like sold, relation with previous years' business, and kilowatt load added will be determined. Suggestions for the coming season are being solicited. The activity in this line will have and has had a great influence in other lines of decorative lighting.

To aid the lighting salesman of the central stations a folder of representative photographs of lighting installations is being compiled under the following headings: aviation lighting, building and monument floodlighting, recreation lighting, and lighting of swimming pools and industrial yards. Photographs will be furnished by central stations from their own files and by manufacturers of lighting equipment. Data on type of equipment used and quantity will be included, but no mention will be made of trade names. It is suggested that other lighting committees follow this plan.

One of the greatest helps in promoting good illumination is education. It is the very enthusiastic opinion of this committee that central station employees should be given an adaptable course in illumination practice and that schools be conducted for architects, electragists, and such interested people. Such schools in the past have been very successful in Los Angeles, San Francisco and should be pushed by the Pacific Coast Electrical Association strenuously as an educational feature. One of the greatest opportunities of the Pacific Coast Electrical Association is the promotion of lighting education, because it is essential to the welfare of humanity.

* Report of outdoor lighting committee, Lighting Bureau, Commercial Section. L. A. Gates, general chairman.

Airport and Airway Lighting*

THE AIRPORT and airways committee has collected and tabulated essential data on a relatively new phase of industrial lighting and power load. The development of this class of business involves considerable promotional work and the tabulation is classified as follows:

1. **As an aid to development—**
   (a). Essentials involved in the selection of the site.
   (b). Cost of landing fields, hangars and drainage.
   (c). Items of lighting equipment for airports.
   (d). Cost of special and standard lighting equipments.
   (e). Methods and facilities of reporting weather.
   (f). Air transit companies operating in California.

* Report of subcommittee of outdoor lighting committee, Lighting Bureau, Commercial Section. W. P. Bear, chairman. F. A. Lavigne, E. P. Markee, F. D. McKinstry, J. W. Wagner, R. R. Walbridge.

(g). Rules and regulations governing airports.
(h). Totals of mail, passenger and express traffic from California airports.

2. **Of special interest to electric utilities—**
   (a). Suitable rate schedules for airport lighting.
   (b). Suitable rate schedules for airways lighting.
   (c). Kilowatt-hour consumption of airport items.
   (d). Revenue from airports and airways in California.
   (e). Lists of proposed and projected airports in California.
   (f). Desirable policy with reference to elimination or removal of obstructions such as trees, utility poles, etc.

3. **Classes of promotional work now being done—**
   (a). By means of window displays.
   (b). By means of illustrated public addresses.
   (c). As a result of favorable publicity.
4. **Benefits to the public utility.**
   (a). Improved Public Relations .
   (b). Attractive and dignified method of advertising.

Finally, the industry is definitely established in California due to the favorable all-year-round weather conditions in this state. There is nothing mysterious about the lighting of airports and airways, but the business is highly special in the matter of lighting.

Domestic Lighting Survey*

THE OBJECTIVE of the domestic lighting committee as outlined under "Program of Activities 1928-1929," that of a survey of 4,000 to 5,000 domestic consumers to ascertain existing lighting load was found to be impracticable at this time, for the particular reason that domestic lighting activities among Western utilities which could be served by this survey were not comparable.

However, an overall observation surely justifies a program of domestic lighting sales to increase the average domestic lighting load (948 watts). Whether this should be in the nature of a refixturing campaign or the direct sale of portable home lighting equipment containing higher wattage lamps, would be a matter for the specific utility to decide.

This committee does not presume to recommend any procedure whatever, but the study of lighting emphasizes the fact that lighting contributes the greatest amount of revenue with the smallest number of kilowatt-hour sales, and that little if any credit can be taken by the utilities for this revenue through the medium of creative sales, in other words, the public bought its own lighting.

Existing domestic lighting conditions, with glare due to unshaded light, have contributed to the defective vision of the public, and this fact alone justifies the utility in assuming the "indirect" responsibility of advising its consumers of how to use light properly.

This one customer recommendation alone would be an outstanding consumer service and a big factor for good will. Additional revenue would result for the class of lighting to eliminate the objectionable features of glare would be the indirect or semi-indirect type, and its efficiency depends upon the use of 200-watt lamps and upwards.

In the year's study of domestic lighting this committee has accumulated voluminous data containing information of all the various campaigns conducted by all United States utilities and suggested a lighting sales plan but does not recommend their publication for general distribution due to the expense, but stands ready to lay before any association member complete details.

In conclusion it is our opinion that domestic lighting is a lucrative field for the utility in developing revenue from its present consumers by selling equipment on existing facilities, but to do so the electrical industry must **educate, instruct, demonstrate** and **persuade.**

* Report of domestic lighting committee, Lighting Bureau, Commercial Section. Frank Bevan, chairman. R. W. Buckles, O. S. Clifford, G. H. P. Dellmann, E. W. Garcia, C. E. Houston, E. P. Markee, C. L. Simonds, A. E. Strong, J. H. Wagner, W. J. Walsh.

Industrial Lighting—Its Value and Importance*

In the preparation of this paper the chief aim has been an endeavor to awaken in the central station employee a realization of the extreme importance of good illumination, its value to the central station as a revenue producer, the increasing necessity of its employment in industry and to enlist and encourage his co-operation in its promotion and sale.

Central station sales managers, lighting department personnel and some few others are quite aware of the part that lighting is playing in load-building programs and of the unlimited possibilities that it offers for the future. Employees in the operating and service departments of these companies, however, do not have the opportunity to hear the lighting story that is being told to those in command. It is to these employees, therefore, that what follows is primarily directed—not for the purpose of making lighting men of them, but for the purpose of creating interest in better lighting and to enable them to recognize the difference between good and bad lighting installations, as well as to fit them to give intelligent answers to the many questions on lighting that are daily being asked by consumers.

CONTINUAL advances in standards and practices in industry and commerce have placed ever-increasing demands on the electrical industry for higher and higher levels of illumination. What is considered good practice and essential today in adequately lighted factories is four or five times that which was deemed satisfactory ten or fifteen years ago. This progress has dropped by the wayside as obsolete, from the standpoint of illumination, 60 per cent of the country's industrial establishments which are today awaiting modernization through the services of the lighting specialist.

That a more intelligent and fuller use of electrical energy for lighting is not utilized in so large a portion of the factories of today is perhaps due to a lack of knowledge on the part of the factory owner; first, of the extent of the inadequacy and; second, of a remedy. In that the central station maintains at all times a close contact with each and every one of these plants, it is the thought that there is an especially fine opportunity for the contact man, be he in the operating or in the service department, to determine the matter of inadequacy and if possible call it to the attention of the responsible party. This will start the ball "a'rolling" and, where the central station maintains a lighting service department, as it should, the contact man may then see to it that this department suggests the remedy.

* Report of industrial lighting committee, Lighting Bureau, Commercial Section. J. E. Hammond, chairman. F. E. Carew, L. G. Gianini, R. A. Gulick, F. A. Lavigne, R. V. Ludlum, C. O. Martin, J. O. Presbrey.

How to Gage the Effectiveness of a Lighting System

As a guide to the central station employee in how to gage the effectiveness of a lighting system and to determine whether or not the work space in question measures up to modern standards of illumination, the following list of requirements should be observed:

1. **There Must Be Adequate Light For The Work**—Do men carry their work to the windows for fine measurements? Are lamps of low wattage? Do workmen crouch over their work, or do they work easily and naturally? Do any operations, because of their fineness, require a higher degree of illumination than supplied by the general lighting system?

2. **There Must Be Freedom From Both Direct And Reflected Glare**—Are there any bare or unshaded lamps? Are clear lamps used in old-fashion shallow shades? Are there any bare or unprotected lamps in the direct line of vision, causing workmen to squint at their work? Do eyes tire quickly?

3. **Lighting Units Must Be Located So As To Eliminate Harsh Shadows and Sharp Contrasts**—Are there any dark corners? Is part of the room brightly lighted and other parts dark? Can workmen easily find tools dropped under machines or benches? Are any workmen working in their own shadow or in the shadow of a machine? Must the eyes re-focus in looking about the room? Are reflectors too far apart?

4. **There Must Be A Fair Degree Of Illumination On Side Walls and Ceilings**—Do the lighting units appear white spots against a dark curtain? Is the working scene gloomy and depressing? Is it difficult to distinguish the outlines of walls and ceilings? Are the walls and ceilings dirty?

5. **The Lighting Equipment Should Be Suitable For The Specific Service Condition Under Which It Is To Be Used**—Is the reflector shape and type of construction acknowledged the most suitable to meet service conditions in the plant? Are special lighting units required to supply higher intensities than provided by the general lighting system? Should the equipment be gas and vapor proof? Should the light be diffused or softened? Should the equipment be constructed to resist corrosive fumes and vapors and the rusting effect of moisture?

6. **The Lighting System Should Be Simple, Reliable And Easy to Maintain**—Are reflectors and lamps dirty? Are there any empty sockets or dead lamps? Have any reflectors deteriorated? Has provision been made for keeping lamps and reflectors clean in dusty or dirty locations?

Terms and Definitions

Foot-candle: the unit of intensity of illumination. It is equal to the illumination falling normally upon a surface one foot distant from a one candle-power source. Present day standards of lighting are expressed in foot-candles and tables giving levels of illumination for most industries and classes of business are available, together with simplified methods of determining outlet spacings, lamp sizes and mounting heights to obtain the desired results.

Glare: a condition of lighting which, on account of high brilliancy or excessive contrast, produces an unpleasant sensation or interferes with vision. It is a common fault in most lighting installations and is usually due to bare unshaded lamps or to improperly placed units allowing reflections from highly polished surfaces.

Diffusion: that quality of light produced by the presence of irregular cross rays, as distinguished from parallel rays or those radiating from a point source such as a bare lamp filament. It is secured by the use of reflectors which increase the apparent dimensions of the light source. Diffusion improves the seeing value of light by lessening deep shadows and reflected glare.

General Illumination: the method of lighting an interior whereby an attempt is made to give an equal intensity of light throughout the entire room. It is accomplished through the use of relatively large units symetrically spaced and properly equipped with reflectors hung overhead out of the way, as opposed to the old practice of localized lighting with drop cords, often with bare, unshaded lamps.

Modified General Illumination: this term refers to the practice of supplementing the general illumination with specially located units, so as to give the maximum intensity of light over machinery or processes where most desired and at the same time provide a lower but adequate working illumination in the intermediate spaces.

Bare Lamp: a lamp used without shade, reflector or globe. It is one of the common faults in old, obsolete lighting installations and is the cause of everything that is undesirable in lighting. No bare lamps should be permitted in working spaces.

Reflector: an accessory which, together with a lamp, goes to make up a lighting unit. Its first purpose is to reduce the glare from the unit, protecting the eye from the intense brilliancy of the bare lamp filament. The undesirability of glare cannot be over-emphasized. Its second purpose is to redirect the light rays in such a manner as to utilize them most efficiently, sending the maximum amount of light where it is desired. The third function of a reflector is to add to the diffusive qualities of the light and thereby reduce the harshness of shadows.

Types of Reflectors

Though various types of reflectors are used, the most common and that generally accepted as standard for industrial lighting today are reflectors made of porcelain enamelled steel. They are rugged, easy to clean and accomplish the purposes for which they are intended economically and well. They are available in flat cone, shallow bowl, deep bowl, angle and standard R.L.M. dome shapes. The first of these really has no application for interior lighting, owing to its lack of hooding effect, and should never be used. The shallow bowl also lacks this hooding effect and should be used sparingly. The angle reflector has its place where lighting must be done from the side and where it is impractical to light from above. The deep bowl type possesses advantages for the local lighting of small areas over benches or machines, but should never be used for general lighting.

The R.L.M. Standard Dome Reflector—The R.L.M. dome reflector shape is so called for reason of its adoption by reflector and lamp manufacturers as standard for general illumination of industrial interiors. It is so shaped as to illuminate both horizontal and vertical surfaces and its 17.5 deg. angle of cut-off well protects the eyes of workers against glare. The R.L.M. standard dome reflector together with white bowl Mazda C lamp is perhaps the best all-around combination for general factory lighting available at the present time.

The Glassteel Diffuser—This unit combines the diffusion and high reflecting efficiency of a white porcelain enamel reflector and the diffusive properties of a translucent glass enclosing globe. It produces a soft, evenly diffused light over the entire working plane with a minimum amount of direct and reflected glare. Approximately eleven per cent of the total light output escapes through apertures in the top of the reflector, relieving harsh ceiling contrast and imparting to the entire room a bright, cheerful appearance. It has the same general application as the R.L.M. standard dome reflector, but may be said to excel in the quality of illumination produced.

Use of Proper Lamps in Reflectors

It is of extreme importance that the proper size lamp is used in the reflector for which it is designed.

All well-designed reflectors are made for use with a certain size lamp whose physical dimensions, such as size of bulb and light center length, are standard. The use of the wrong size lamp results in the light center being either too high or too low, which, in turn, causes poor distribution or glare.

Results of Improper Voltage Applied to Lamp

Lamps made by reputable manufacturers are so designed that a maximum of light output and life of lamp are secured when the lamp is operated on voltage for which it is designed.

Proper Maintenance of Lighting Equipment

A lighting installation, like any piece of mechanical equipment, will depreciate with time if no efforts are made to keep it up to full working efficiency. Dust will accumulate on lamps and reflectors, lamps will fall off in candlepower and unless steps are taken to maintain the installation, the illumination provided by the system will gradually decrease.

In many cases, from one-fourth to two-thirds of the light paid for is lost through lack of attention to proper maintenance. This is an appreciable direct and useless loss but the indirect losses are even greater. In the factory, reduced illumination means lower production, greater spoilage and more accidents. The principal causes of depreciation are: dirty reflectors and lamps, lamps of poor quality, improper voltage, blackening of lamps.

An actual test of a lighting installation was recently made in a machine shop. The installation consisted of glassteel diffuser units. The units were removed and photometric tests made. The results of these tests showed that due to dust and dirt that had accumulated, the units were delivering only one-fifth as much light as when first installed. After cleaning, they were again restored to their original efficiency. This condition meant that for every dollar spent for current, eighty cents were wasted.

This case is the rule rather than the exception, though in varying degree, and many a splendid lighting installation proves unsatisfactory due to lack of attention. The best lighting installation after being in service for some time becomes unsatisfactory. A casual inspection shows dirt, dead insects, and accumulations of all sorts on the lamps and inside of reflectors. The use of a little soap and water will restore the installation to its former satisfactory condition.

Lighting equipment requires the same care and attention as any electrical or mechanical piece of apparatus. No plant engineer would tolerate dull tools, dirty boilers or improperly oiled machinery. Why, then, should lighting equipment be allowed to become inefficient through lack of care?

Three classes of dirt are commonly encountered in maintaining a lighting installation, i. e., dry dust, oily dust and grease, and paint, tar and varnish. Soap and warm water will remove most of the dirt, but it may be necesasry to use some solvent such as acetone or benzine to remove paint and tar, but care should be exercised, as these are highly inflammable.

Effect of Dark Walls and Ceiling

While the eye is remarkably flexible and adapts itself to a wide range of intensities, harm results when it is subjected to frequent adjustments in shifting from brilliantly lighted areas to dark walls and ceilings. The result is eye strain, which reacts on the nerves to cause tiring, discomfort and pain.

From the psychological standpoint, light walls and ceilings lend an air of cheerfulness and wide-awakeness to a room, which is lacking where sharp contrasts exist.

In that a considerable portion of the light from a well designed system of illumination falls on the walls, or is reflected from the work to the ceiling, the efficiency of the system is obviously effected by the power of the walls and ceiling to, in turn, reflect back to the work a part of this incidental light. When it is realized that the reflection factor of white finished surfaces may be as high as eighty per cent and that of dark surfaces as low as five per cent to ten per cent, the importance of giving consideration to color of walls and ceilings is at once apparent.

Planning for the Future

The foregoing has to do mainly with plants already built and in service. Where new plants are under consideration, is it recommended, in view of the continual advances in standards and practices in industry and the ever-increasing demands for higher and higher levels of illumination, that wiring be installed for an increase of at least fifty per cent of the originally designed load. This is entirely justifiable and where this provision is made at the time the building is being constructed, this increase may be had for little more than 10 per cent additional cost—a sound investment as insurance against obsolescence. Warehouse and storage spaces in industrial plants are invariably being changed to working areas due to expansion and growth, and where provision is made in the wiring system for this eventuality, increases in lighting intensities may be had with a minimum expenditure of time and money.

MERCHANDISING BUREAU REPORTS[2]

DURING the current year the general bureau of the Commercial Section has been primarily concerned with the organization and administration of an employee educational campaign through the medium of a new type of essay contest. Heretofore, the contest has been of a purely public relations nature based upon routine employee conduct toward the consuming public. This year the basis of the educational work, and its allied contest, has been changed to one of public relations through employee sales contact.

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[2] **H. C. Rice,** Southern California Edison Company, chairman. **Myron McNeal,** Southern California Edison Company, vice-chairman. **Apex Heater Sales Company:** Arthur Kempston. **George Belsey Company:** George Belsey. **California Electragists:** C. J. Geisbush. **Barker Brothers, Inc.:** E. A. Norton. **Central Arizona Light & Power Company:** C. T. Yaes, R. A. Best, J. F. Quinn. **California Hardware Company:** E. P. Hallock. **Easy Housekeeping Shop:** F. E. Ford. **Edison Electric Appliance Company:** R. H. Robinson, Malcolm White, P. H. Booth, J. P. Bowdon, G. W. Cole, R. W. Turnbull. **Eureka Vacuum Cleaner Company:** J. H. Harvey. **P. A. Geier Co.:** H. D. Mills. **General Electric Company:** G. J. Ruck, G. F. West. **Graybar Electric Company, Inc.:** H. C. Gildrick, R. W. Kimberlin. **Fobes Supply Company:** R. F. McDonald. **Great Western Power Company of California:** O. R. Doerr, O. F. Anderson, M. C. Pfyl, J. W. Wrenn. **Illinois Electric Company:** D. C. Pence. **Listenwalter & Gough, Inc.:** C. E. Louis, F. C. Doyle, Elbert Kramer. **Ironrite Ironer Company:** J. D. Paladeaux. **Los Angeles Bureau of Power & Light:** A. W. Elliott. **Majestic Electric Appliance Company:** H. A. Mulvaney, M. J. Murphy, J. J. Murphy. **Newbery Electric Corporation:** D. T. McFarlane. **Pacific Gas and Electric Company:** J. L. Farley, L. F. Galbraith, E. F. Perkins. **Pacific States Electric Company:** A. W. Kreuger, F. C. Todt, R. E. Tompkins. **San Diego Consolidated Gas & Electric Company:** P. P. Pine, E. W. Meise. **San Joaquin Light & Power Corporation:** M. P. Lohse, A. M. Frost. **San Francisco Underwriters Laboratory:** R. J. Larrabee. **Sierra Pacific Power Company:** O. S. Clifford. **Southern California Edison Company:** A. W. Althouse, H. H. Douglas, R. G. Kenyon. **The Southern Sierras Power Company:** W. S. Fleming, G. T. Bigelow. **Syracuse Washing Machine Company:** F. S. Fenton. **Swartzbaugh Manufacturing Company:** E. J. Baughman. **J. W. Robinson Company:** A. G. Fisher. **Valley Electrical Supply Company:** H. H. Courtright. **Walker-Pratt Manufacturing Company:** B. Y. Gibson. **Wesix Electric Heater Company:** C. B. Merrick, Adolph Strauch. **Wolfsberg Company:** R. R. Wolfsberg. **Westinghouse Electric & Manufacing Company:** J. H. Jamison, M. S. Hennoch, C. H. Paulin.

An increased and improved domestic use of electricity was first adopted as the logical foundation for a consistent year-to-year employee educational program. Since a home must be adequately wired in order to utilize properly additional electrical servants, it was obvious that power company employees should be educated as regards a complete and recognized standard of adequacy.

The Red Seal plan was accordingly adopted as the standard, and the employee educational committee under the leadership of E. F. Perkins set about the preparation of a manual "Why I Should Like to Own a Red Seal Home" to be used by entrants in the forthcoming contest as the basis of their essays. The completed booklet dramatically establishes the fallacy of inadequate wiring and fully outlines the Red Seal plan as the remedy.

As this report goes to press, a total of 1,200 employee essays have been received, outlining the value of the Red Seal plan from the standpoint of the home maker, the home owner and the power company. The 39 best answers will receive a total of $900 in cash prizes.

The preparation of these essays has required not only close study of the manual but also a considerable amount of personal research on the part of the employee contestant.

It was to be expected that the total number of essays submitted under these circumstances would be less than the number which might be submitted in a relatively more simple contest based on routine consumer contact. On the contrary, however, this year's entries exceed last year's by 300 papers. In addition to the direct value of the actual essays, a total of 15,000 Red Seal booklets remains in the hands of contact employees to be used as a permanent guide toward adequate home wiring.

On account of the evident cash register value of the work, the incumbent general bureau commends a continuance of this line of educational activities to the incoming general bureau organization.

A Revised Manual on Electric Air Heating*

THIS manual is intended to present definite and reliable information relative to electrical air heating. The data are based on many years of practical experience and have been accumulated from hundreds of installations.

This manual shows:

1. The advantages to the user of electric heat.

2. A method of estimating the sizes of heaters required for various installations.

3. A method of calculating energy consumption.

4. Tables of heat losses by conduction through various materials.

5. Tables of average temperatures.

6. Some actual data on energy used in existing installations.

No attention is paid in this manual to sales methods, plans or programs.

General

The use of electricity for the heating of air is becoming daily more extensive. A check of the sales by electric heater manufacturers clearly reveals this fact. Sales are of marked volume and are reported as increasing rapidly. This is true because of the increasing familiarity on the part of the public; the convenience, safety and ease of control afforded and the recognition of the growing importance of this service as a load builder for central stations. Many power companies are actively soliciting this type of load because of its earning power. Salesmanship is not alone responsible for this load development. The merit of this type of heating is evidenced by the rapidly increasing number of satisfactory installations, each of which contributes to the further advance of the business.

The advantages in the use of electricity for air or space heating, as it affects the consumer, central station, manufacturer or merchandiser of equipment, bear worthy consideration. To have reached even its present stage of development this service must have been of real benefit to the consumer and of profit to the power company, as well as to the selling agencies.

Too much information is already available on this subject to go into intimate detail in this manual. It is general knowledge that there are thousands of satisfied users of this form of electric service and that many power companies regard the load as very attractive. Many companies have indicated their intention more actively to solicit this type of load and the growing number of installations refutes any thought that electric air heating is not acceptable to the public.

Manufacturers and merchandisers of electric air heating equipment may find it necessary to redirect their channels of distribution. They will, too, undoubtedly be compelled to give more thought and attention to intelligent publicity.

Local conditions, such as climate, prevailing temperatures, generating and distribution costs (reflected in rates), type of building construction, habits of users and other factors exert a material influence upon the growth of the business. The colder winter climates of the Middle West and Eastern states offer somewhat more of a problem in the use of electric heat as a primary system than the milder climates of the Southern and Pacific Coast states, but this problem is common to all heating systems. Sections enjoying low steam or hydro generating costs are in a better position to benefit from electric heating than those less advantageously situated. It is, therefore, not remarkable that electric air heating had its practical inception on the Pacific Coast and that its growth in that area has been phenomenal. However, it has been demonstrated that electric air heating is practical in nearly every section of the country.

Regardless of its geographic location any well constructed building can be heated to comfort with electricity. Decision as to the use of electric heat must be based on a comparison of its relative advantages and cost with the disadvantages and cost of fuel.

Advantages

The major advantages of electric heat are:

1. **Healthfulness.** The air is not vitiated either by the generation and discharge of noxious fumes or by the combustion of oxygen. No moisture is created —because there is no combustion.

2. **Cleanliness.** No smoke, soot, grease, dirt, moisture or disagreeable odors are given off.

3. **Convenience.** No fuel or ashes have to be stored or handled. No fires have to be lighted, watched or otherwise tended. Furniture, fixtures and draperies are not harmed. Refinishing of walls is not occasioned. Temperatures may be controlled either manually or automatically. Heaters may be moved from place to place or may be permanently mounted where they will render the best service. Heat is available instantly without the delay experienced with steam, hot water and other heating systems.

4. **Safety.** When electric heaters have been so designed and constructed as to meet the requirements of the Underwriters' Laboratories of the National Board

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* Report of subcommittee of electric air heating committee, Merchandising Bureau, Commercial Section. E. A. Wilcox, chairman. G. W. Barker, R. C. Bragg, W. W. Hicks, Arthur Kempston, H. E. Mulvaney, Adolph Strauch.

of Fire Underwriters, and have been properly installed, they represent the safest type of heating equipment that can be obtained.

5. **Economy.** In properly designed heaters all of the energy consumed is applied to useful work. No other heating equipment works at such high efficiency. Chimneys and flues are unnecessary, as are coal bins and ash pits or oil tanks. Construction expense is thereby reduced, space is saved, investment lowered and carrying charges materially lessened.

Complete Electric Homes

Due to the cost and difficulty of obtaining competent servants, many families in modest circumstances make their homes of from five to eight rooms completely electric, including lighting, cooking, water-heating, air-heating and appliances. In such cases the housewife can readily do the daily tasks herself without great exertion. The total yearly cost for such electrically equipped homes averages from $175.00 to $325.00 per year where the temperature does not go below 20 deg. F. and electricity is available at an average rate not exceeding 2½c per kw.-hr. Such conditions now obtain in large areas. The costs are well within the range of a large class of people, when the saving in other ways is taken into consideration.

TABLE I—Watts loss per sq. ft. of surface for various temperature difference expressed in degrees F.

Nature of Surface—	10 deg.	20 deg.	30 deg.	40 deg.	50 deg.	60 deg.	70 deg.
Single Glass	3.0	6.0	9.0	12.0	15.0	18.0	21.0
Double Glass	1.7	3.4	5.1	6.8	8.5	10.2	11.9
Single Skylight	3.5	7.0	10.5	14.0	17.5	21.0	24.5
Double Skylight	1.8	3.6	5.4	7.2	9.0	10.8	12.6
8-in. Brick Wall	1.3	2.6	3.9	5.2	6.5	7.8	9.1
8-in Brick Furred and Plastered Wall	0.7	1.4	2.0	2.7	3.4	4.4	4.7
12-in. Brick Furred and Plastered Wall	0.6	1.2	1.8	2.4	2.9	3.5	4.1
24-in. Brick Wall	0.6	1.2	1.8	2.4	3.0	3.6	4.2
8-in. Concrete Wall	1.6	3.2	4.8	6.4	8.0	9.6	11.2
8-in. Concrete Furred and Plastered Wall	0.8	1.6	2.5	3.3	4.1	4.9	5.8
12-in Concrete Furred and Plastered Wall	0.7	1.5	2.2	2.9	3.7	4.4	5.1
24-in. Concrete Wall	0.7	1.4	2.1	2.8	3.5	4.2	4.9
4-in. Hollow Tile, plaster both sides	1.5	3.0	4.5	6.0	7.5	9.0	10.5
8-in. Hollow Tile, plaster both sides	1.2	2.4	3.6	4.8	6.0	7.2	8.4
4-in. Tile, Stucco and Plaster Wall	1.0	2.0	3.0	4.0	5.0	6.0	7.0
8-in. Tile, Stucco and Plaster Wall	0.8	1.6	2.4	3.2	4.0	4.8	5.6
Corrugated Iron	3.3	6.6	9.9	13.2	16.6	19.9	23.2
Wire Lath and Plaster	1.9	3.8	5.6	7.5	9.4	11.3	13.1
Frame Wall with Clapboard only	1.3	2.6	3.9	5.2	6.5	7.7	9.0
Frame Wall with Sheathing and Paper	0.8	1.6	2.5	3.3	4.1	4.9	5.8
Frame Wall with Sheathing and Asbestos	0.7	1.4	2.0	2.7	3.4	4.1	4.7
Frame Wall, plaster outside	1.3	2.6	3.9	5.2	6.5	7.8	9.1
Frame Wall, double board outside	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Partition, lath and plaster both sides	1.2	2.4	3.6	4.8	6.0	7.2	8.4
Plaster one side	2.0	4.0	6.0	8.0	10.0	12.0	14.0
Partition, 1-in. wood	1.8	3.6	5.4	7.2	9.0	10.8	12.6
Partition, 2-in. wood	1.2	2.4	3.6	4.8	6.0	7.2	8.4
Wooden Floor, double board	0.3	0.5	0.8	1.0	1.3	1.5	1.8
Concrete Floor	0.9	1.8	2.7	3.6	4.5	5.4	6.3
Wooden Floor on Concrete	0.4	0.8	1.2	1.6	2.0	2.4	2.8
Dirt Floor	0.6	1.2	1.8	2.4	3.0	3.6	4.2
Plaster Ceiling, no floor above	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Plaster Ceiling, floor above	0.8	1.5	2.3	3.0	3.8	4.5	5.3
Wooden Ceiling, composition roof	0.9	1.8	2.7	3.6	4.5	5.4	6.3

Watts per cu. ft. of air required to heat air = 0.0054 per degree of temperature difference

Note:—The accuracy of these tables cannot be guaranteed for the reason that no two authorities seem to agree exactly. However, these figures have been used for some time with very satisfactory results, and they are certainly sufficiently correct for ordinary purposes.

Complete Electric Apartment Houses

Apartment house owners have come to realize the advantage of electric heating—which eliminates the services of a janitor and the necessity of operating continually a central heating system for the convenience of a few tenants who might require almost constant heat. Electric heat is available to each tenant at any hour that it may be required. Energy for these apartments is usually purchased on a master meter and resold to the tenant on a sub-meter. In this way a low average rate is earned. Some apartment house owners sell for a lower rate than that which they pay, but are justified in doing so inasmuch as all attendant and repair charges are eliminated.

TABLE II—Average Monthly and Yearly Temperatures San Francisco, California

	1926	1925	1924	1923	1922	1921	1920
January	47.9	51.4	50.2	48.1	46.8	49.5	52.0
February	56.0	55.2	57.0	52.2	50.2	52.9	52.8
March	60.6	55.4	54.5	56.8	52.4	54.6	52.6
April	61.6	57.0	57.4	56.1	53.5	54.9	54.9
May	61.0	59.0	59.1	57.2	58.0	54.4	55.8
June	59.2	60.7	59.8	57.2	60.0	62.4	60.0
July	61.1	61.2	59.0	60.8	60.2	59.8	57.8
August	60.8	61.2	59.1	60.6	60.4	59.6	60.0
September	61.2	62.7	62.4	64.0	63.4	63.3	64.0
October	63.4	62.2	59.4	62.5	60.6	61.5	60.2
November	60.9	56.6	57.2	60.8	54.3	57.8	56.2
December	51.5	51.2	47.8	51.0	50.6	53.0	51.0
Average	58.7	57.8	56.9	57.2	55.8	56.9	56.4

Hotels

A number of hotels have been equipped electrically with the result that they are giving entire satisfaction where a sufficient capacity of the proper kind of heaters has been installed. It is usual in making an installation in a hotel to install the distribution panel controlling each heater in the office so that the clerk in charge can turn on the heater as soon as the room has been let. The heater is then operating by the time the occupant arrives in the room. The switch can also be pulled when the key is returned to the desk if so desired.

Schools

This subject is covered in detail in a separate report.

Churches

Buildings of this description require heat but a few hours per month with the result that they must have a system which will quickly heat the whole or any portion of the building. The low cost and flexibility of electric heating systems are particularly adapted to this class of building. The load is also more or less off-peak in character.

TABLE III—Average Monthly and Yearly Temperatures Fresno, California

	1926	1925	1924	1923	1922	1921	1920	Normal*
Jan.	43	48	47	46	42	46	48	46.3
Feb.	54	54	56	50	50	52	52	51.1
Mar.	61	57	54	57	53	57	53	55.0
Apr.	66	61	62	59	57	59	59	60.1
May	70	69	73	67	69	64	68	67.1
June	80	77	77	69	76	76	75	75.7
July	84	84	80	80	84	84	79	82.1
Aug.	80	79	80	79	79	80	82	80.7
Sept.	72	69	75	76	79	73	72	73.3
Oct.	67	63	62	64	64	67	60	64.0
Nov.	61	54	55	58	51	57	54	54.2
Dec.	47	46	45	46	50	50	48	46.3
Average	65	63	64	63	63	64	62	63.0

*39 Years Average. U.S.W.B. Records.

Offices

Employers are recognizing the advantage of supplying to their employees heat from a proper system. Electric heating systems can be regulated uniformly

to the temperature where employees work to the highest efficiency. Pure air with uniform heat and proper ventilation without drafts will often increase efficiency from 10 per cent to 25 per cent.

Bath Rooms

An appropriate electric heater for bath rooms is of particular interest and importance. Its practicability has been demonstrated and it has been proved that the matter of rate does not enter into consideration. It is expected that this form of service will pave the way to heavier installations, particularly in those sections of the country where electric air heating is not now well developed.

Because full temperature is desired in a minimum of time, it is common practice to install bath-room heaters of capacity greater in proportion than those used in other rooms of the house. The tendency seems to be to use, in small bathrooms, heaters of about 1,200 watts to 1,500 watts capacity, but there is a growing disposition to extend this to 2,000 watts. Undoubtedly better service will be rendered and greater satisfaction obtained with the use of the larger sizes, even in small bathrooms. The period of use of these heaters is usually very short, but the results must be immediate.

Bathroom heaters are usually of the flush or permanent type with nickel or white enamel finish to harmonize with the fixtures of the room. This type of heater provides the maximum of available space and safety. Even in houses and apartments where other heat is installed it is a growing practice to install an electric heater in the bathroom, the heater usually being on the tenant's meter. He thereby pays for the service he requires. This practice, in apartment houses, often results in material saving in heating plant operating costs.

Because of the fact that some power companies require a permanently connected heating appliance of 2 kw. before granting special combination or heating rates, this form of application is of special attraction. Not only because of the revenue from this bathroom heater alone, but because of the increased use of appliances where the combination rate is enpoyed, the installation of bathroom heaters becomes a matter for serious consideration by power companies.

Heater Types

Electric heaters are made in flush or permanent type for mounting in the wall; portable type for moving from one location to another; bracket type for fastening on the wall and floor type for mounting beneath the floor, with register set flush in the floor. This latter type is sometimes used for central heating.

Efficiencies of these various types, at the heater, vary only slightly. It is evident, however, that heaters placed within a room will give better heat service than those heaters working through ducts. Central heating is less efficient because of transmission losses, even when the ducts are well insulated. It is also less flexible.

It is ordinarily best practice to install wall or permanent type heaters. Better engineering is usually possible with this type and heaters so mounted become part of the fixtures of the home just as do bath-room fixtures. This type of installation, too, increases the property value.

Investment and Depreciation

Normally the cost of an electric heating installation is much less than that of a first class fuel system. This means a reduced construction cost and a lessened carrying charge on the property.

Depreciation of fuel heating systems is very high and labor and maintenance are considerable items. Depreciation of electric heating equipment may be taken as not exceeding that of the building, and maintenance practically nothing. Labor for operation is nothing.

Frequently there are insurance advantages in completely electrified homes.

Comparative Analytical Study of the Economy of Electric Heating

In making a comparative study of the use of electricity for air heating purposes in competition with other systems of heating, it is very important to consider all inherent costs of the systems and not to stop with a comparison of installation costs or fuel and energy costs only. It is also important to base a comparison on systems which will give equivalent results from a standpoint of comfort, cleanliness, healthfulness, convenience, desirability, flexibility, control features and safety from fire and explosion hazards.

If the comparable service is not equivalent to electric heating, it will suffer the relative value of intangible advantages which introduces the human element. Appreciation of these intangible values will differ with individuals; and it is hard to arrive at a fair comparison. However, when all of the costs and all of the advantages are given due consideration in their proper magnitude, electricity usually has the advantage over any other fuel when the results are based on equivalent heating.

In order to arrive at a fair and competent decision as to the relative economy of electric heating, it is vital that the study be approached without any preconceived ideas as to the merits of the case, with an unbiased engineering sense and without fear of any precedents. All conditions must be understood clearly and conclusions must be formed independent of the personal equation.

It is suggested in making this study that we change our mental attitude and study **comparitive economy** and not **comparative costs.** Train ourselves to think of electricity as being economical. The difference is largely a change in mental attitude. Think of electricity as an economical commodity. Gas may be cheap, but is it economical? Unity of effort and co-ordination of all electrical interests along the line of this thought will get results.

After the capacity and location of all heaters are decided, it is possible to get an estimate on the cost of installation. The cost of installation is very important as the overhead charges are largely dependent upon it.

Operating costs are subject to a wide difference of opinion, but can be quite carefully estimated if conditions are known. If this information is not available, conditions should be carefully assumed, and tentative estimates based thereon.

Actual necessary heating requirements to maintain any given temperature any given time can be determined accurately. The heat losses per degree difference in temperature can be determined accurately for any given building; the temperature deficiency in degree-hours for any given time interval can be determined accurately from U.S. Weather Bureau data. The amount of heat energy necessary for warming incoming air for ventilation can be determined accurately. There can be little or no difference of opinion on these three items; they can all be computed with a high degree of precision and are perhaps subject to very little error in judgment if the investigator has a clear understanding of their application.

The human element cannot be determined, and this is the point on which it is necessary to base assumptions. However, in making the estimate known, conditions should be clearly stated and reasonable assumptions made as to the human element. A clear statement should be made with conditions set forth therein as to operation.

It is suggested that this statement be carefully worded to prevent any possible misunderstanding. The following is suggested as an outline, not as an ideal, but perhaps as a practical method of getting the idea clearly stated: "It is estimated that this building can be heated from (say 6:30 a.m. to 10:30 p.m.) to a temperature of 70 deg. for an entire heating season, under average conditions, and with ——— changes of air per hour, if installed and operated as outlined herein, for approximately ——— kw.-hr. per heating season.

This estimate does not, however, provide for wasteful use of heat, for time other than specified herein, and does not allow for conditions arising in the future not herein specified. It is not to be construed as in any way being a promise or a guarantee, but as a fair and careful estimate of what the heating requirements will be."

TABLE IV—Typical Operating Costs of Electric Heating—Residences—Lighting and Heating Only

San Francisco Loads	9.8 kw.	13.2 kw.	11.9 kw.	14.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	932	970	2,410	988
February	795	1,238	1,021	427
March	409	974	603	158
April	381	472	408	215
May	260	332	377	158
June	160	426	316	89
July	187	139	260	85
August	243	179	412	64
September	240	268	303	80
October	163	186	366	86
November	240	236	426	171
December	262	580	889	276
Total for Year	4,272	6,000	7,791	8,797
Average per Month	356	500	650	233
San Francisco Loads	18.6 kw.	32 kw.	30 kw.	
	Kw.-hr.	Kw.-hr.	Kw.-hr.	
January	1,430	2,350	320	
February	963	1,633	670	
March	435	1,009	420	
April	642	1,181	340	
May	270	754	570	
June	195	448	470	
July	60	39	860	
August	67	33	350	
September	102	43	100	
October	66	62	580	
November	191	140	450	
December	713	823	450	
Total for Year	5,134	8,515	5,580	
Average per Month	428	709	465	

After the heat requirements are determined, this is readily converted into money by use of the proper rate schedule. It is suggested that this be done only by one familiar with the rate schedules and their application. If the total cost is not equivalent to minimum charges, the consumer should be advised thereof.

It is advisable to talk in terms of money when discussing electric heating with the consumer, as he speaks in terms of dollars instead of kw.-hr., maximum demand or load factor.

As a usual thing the cost of operating an electric heating system will be a very small percentage of the total investment or operating charges for the building as a whole.

(A) Cost of Installation: The cost of installation consists of the investment necessary for the purchase of heating equipment, auxiliary apparatus and labor and materials used in the installation thereof. The supporting construction work in connection with a heating system is always less with electric heat than with any other form of equivalent heating. This should be set up as a separate item.

Engineering, consultation services, drawings and design costs should be set up as a charge to the cost of installation. These items run up on a big job.

Sub-basement, stacks, flues and expensive concrete sub-structures are not necessary with electric heating.

A space charge item should be set up based on the unit cost of floor space or cubage used for each system. Include in this item basement space, air shafts, etc., necessary by virtue of the particular competitive system under consideration.

Separate charge items should be set up showing details of cost of all equipment used in construction, such as boilers, furnaces, heaters, flues, stacks, fuel storage, tankage, pumps, piping, connections, blowers, ducts, fire protection and all auxiliary equipment, whatever its nature, used in the heating system.

The cost of additional real estate required for boiler plants, fuel storage, etc., is a big item, and should be set up separately.

On large buildings where light, power and heat are combined on one meter, the electric heating should be charged only with the total additional cost by virtue of its inclusion. If it reduces the average cost of total electric service per kw.-hr., it should be credited with such total reduction in cost, and not charged out at the average cost per kw.-hr. The average cost

TABLE V—Typical Operating Costs of Electric Heating—Complete Electric Homes

	San Francisco 6 rooms	Los Gatos 6 rooms	Belvedere 7 rooms	San Francisco 8 rooms
	Kw.	Kw.	Kw.	Kw.
Air Heating	10.4	21	24	16
Water Heating	5.0	5	5	5
Cooking	7.0	7	8	7
Lights	2.0	2	2	3
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,640	1,450	1,855	1,581
February	1,146	1,420	1,771	1,888
March	930	1,490	1,517	814
April	1,142	1,000	864	694
May	847	560	872	629
June	885	340	630	643
July	762	180	600	635
August	1,028	590	660	904
September	757	500	708	868
October	575	480	449	874
November	671	660	779	647
December	821	870	1,424	806
Total for Year	11,174	9,530	12,129	10,983
Average per Month	931	794	1,011	915

	San Francisco	San Francisco	San Francisco	San Francisco
	Kw.	Kw.	Kw.	Kw.
Air Heating	19.2	30	13.6	10
Water Heating	2.0	5	5	5
Cooking	8.0	8	7	8
Lights	1.2		1.7	1.8
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,560	3,456	1,237	1,361
February	1,620	2,448	1,307	1,228
March	970	1,776	1,534	1,521
April	840	1,248	1,467	758
May	740	1,008	1,015	913
June	680	1,008	857	1,056
July	500	1,056	473	1,220
August	730	1,056	261	1,743
September	440	1,056	334	1,218
October	580	1,104	667	861
November	890	1,920	999	1,156
December	1,150	2,016	1,164	1,156
Total for Year	10,700	19,152	11,315	14,187
Average per Month	890	1,563	943	1,182

per kw.-hr. of heat energy would be the total increased cost divided by the kw.-hr. used.

Furthermore, in computing heating hours for fuel and electric consumption, it should be clearly understood that fuel and electrical "heating hours" are not comparable. The flexibility of electric heating as applied in this instance is one of its major inherent advantages.

(B) Overhead Charges: Overhead charges are an operation cost just as much as fuel and any costs of operation and should be classified as overhead charges, if their nature is such as to be unaffected by opera-

tion or non-operation of the heating system. In other words, overhead charges are going on whether heat is being actually used or not.

The principal item of overhead charges may be classified as follows (these would be averaged from an estimated total or a life of 30 years, the average useful life of average building due to obsolescence and changing property values):

1. Interest on the investment.
2. Taxes, licenses, permits, etc.
3. Depreciation and obsolescence reserves.
4. Insurance of all kinds (do not overlook boiler insurance).
5. Administration expense (allocated in proportion to labor costs).
6. Compound interest on the savings in operation on one system over the other.

(C) Operation and Maintenance Costs: The principal operating charges are as follows (these should be averaged from an estimated total of at least ten years operation):

1. Cost of fuel or energy (effect of trend of fuel costs).
2. Cost of other operating materials, water, oil, compounds, etc.
3. Cost of replacement parts of equipment and machinery.
4. Cost of cleaning and painting relative parts of building and equipment.
5. Operating labor.
6. Labor on repairs and replacements of equipment.
7. Rental value of basement space used for heating plant.
8. Charge for space required for the heaters themselves in floor space.
9. Interest on fuel cost in storage.

TABLE VI—Typical Operating Costs of Electric Heating—All-Electric Flats and Individual Apartments—Lighting and Heating Only

	San Francisco 3 rooms	San Francisco 4 rooms	San Francisco 6 rooms	San Francisco 6 rooms
	Kw.	Kw.	Kw.	Kw.
Air Heating	6	6	12	6.6
Water Heating	5	5		
Cooking	5.6	6.5		
Lights	1.0	1.0	1	1.1
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	391	412	1,680	203
February	397	349	925	64
March	74	746	85	55
April	336	958	83	113
May	324	786	53	102
June	553	352	46	88
July	154	265	98	35
August	158	207	67	66
September	179	225	76	43
October	300	532	71	50
November	295	234	118	92
December	346	316	321	120
Total for Year	3,509	5,382	3,623	1,031
Average per Month	292	448	302	86

Thorough Insulation of Buildings

Thorough insulation of buildings is now recognized by all heating engineers and architects as being of primary importance. While it is equally important to insulate thoroughly against heat losses when fuel heating plants are used or when electric heaters are used, only the most progressive of the heating manufacturers are properly emphasizing the importance of such insulation.

If the building is heated with electricity, the bills are rendered monthly, and, hence, the cost of operation and the economy are emphasized monthly when the bill arrives, whereas, with fuel heating plants, fuel is usually obtained twice a year, and the user rarely knows very closely his actual cost.

Savings in fuel costs as high as 40 per cent have been effected merely by a slight investment in insulation of the building. According to the U.S. Bureau of Industrial Research the fuel saved by insulating a building will, in three years, pay for the cost of insulation.

Insulation of buildings always helps to provide even heat distribution.

Calculation of Heater Capacities

It will, of course, be recognized that in calculating the heating requirements for extreme conditions—such as buildings with very high ceilings—judgment must be used as to the compensating factor to be employed. The value of this factor will be materially affected by the convection characteristics of the equipment.

In making calculations of the heater capacities to create and maintain proper temperatures, the following must be considered:

1. Area of exposed glass.
2. Area, construction and exposure of outside walls.
3. Area and construction of inside walls and temperature of adjoining rooms.
4. Area and construction of floor and conditions under floor.
5. Area and construction of ceiling and whether attic or floor above.
6. Volume of air in room and number of air changes required per hour. Air leakage should be considered as it affects the number of air changes.

High temperature radiant reflector type heaters primarily are adapted to heating limited areas rather than for uniformly raising room temperatures. Calculations for radiant heating are entirely different from those of convection heating, and the following discussion is limited to the subject of convection air heating only.

As the majority of electric heaters are rated in watts all radiation losses will be given in watts rather than in B. t. u. One watt-hour is equivalent to 3.412 B. t. u.

Table 1, computed from reliable sources, gives the watts lost by radiation per sq. ft. of surface of different building materials for each 10 deg. F. difference in temperature between that of the room to be heated and the surrounding air.

To calculate the volume of air, multiply the cubical contents of the room by the number of air changes required per hour.

In residences it is customary to calculate two changes of air per hour, but where there are many leaks around doors and windows this should be increased.

In schools, churches, theaters, halls, shops, etc., the law requires 30 cu. ft. of fresh air per person, but as each occupant of the room gives off a certain amount of heat, it is only necessary to figure on the heating of from two to four changes per hour according to the number occupying the room.

Where sides of buildings are exposed to prevailing winds 10 per cent to 25 per cent should be added to the radiation losses of the surfaces exposed.

When buildings are heated only intermittently with long intervals of non-heating, capacity of heaters should be increased at least 10 per cent. Never install under-capacity heaters as over-capacity heaters will insure greater economy and more satisfactory service.

Example

The following example indicates the method of determining the size of heaters for different types of buildings:

Living room 14x20 ft. with 9 ft. ceiling, having two outside walls, 20-ft. wall exposed to winds. Glass area 75 sq. ft. Frame construction, plastered inside, boarded and plastered outside. Double wood floor,

plastered ceiling, no floor above. Two air changes per hour. Difference between outside and required room temperature 30 deg. F.

Refer to Table 1 under 30 deg. F. temperature difference in order to determine the watts lost per sq. ft. for each particular surface.

The following gives the method of making calculations:—

Glass area	× watts lost per sq.ft.	=
Outside wall (less glass area)	× watts lost per sq.ft.	=
Allowance for area exposed to prevailing winds		=
Inside wall area	× watts lost per sq.ft.	=
Floor area	× watts lost per sq.ft.	=
Ceiling area	× watts lost per sq.ft.	=
Volume of room × air changes per hour × watts required per cu.ft.		=
Total watts required		=

In making the calculations for residence heating, each room should be figured separately.

EXAMPLE 1

Residence Living Room

Surface—	Area sq.ft.	Watts Loss per sq.ft.	Watts Loss
Glass	75	9.	675
Outside wall	14′ + 20′ × 9′—75	3.9	901
Inside wall	14′ + 20′ × 9′	1.2	367
Floor	14′ × 20′	.75	210
Ceiling	14′ × 20′	3.	840
Air	14′ × 20′ × 9′ × changes × 30° × .0054		816
Exposed area	20′ × 9′ × .25′	3.9	176
Total watts required			3,985

It will be noted that the watts required in this room are 1.58 per cu. ft., which means nothing for purposes of calculating in other examples. For quick estimating a figure of 0.6 watts per cubic foot per 10 deg. F. difference in temperature between room and outside air may be used by a novice. However, an experienced electric heating engineer's offhand guess will usually be more accurate. The constant is only roughly approximate and will seldom check with calculations. It should not be used where the volume is less than 1,000 cu. ft. or greater than 5,000 cu. ft. As the volume increases the watts required per cu. ft. decrease. This is due to the radiating surfaces not being increased in direct proportion to the volume.

Office Buildings

In the case of office or other buildings having a large number of rooms, unless it is definitely known that all rooms are to be heated and used at all times, each room should be treated separately, and losses computed for the inside walls as well as the floors and ceilings. This will always result in the installation of much larger capacity heaters than would be installed if a steam plant were used, but it is desirable for the reason that the electric heat is used differently from steam.

In the case of a steam plant, when the heat is on, the complete building is usually warmed regardless of whether or not all rooms are occupied, so that interior wall, floor and ceiling losses can be eliminated. Furthermore, there is little or no possibility of regulating the steam radiators unless thermostatic control is employed. Where an electric heating system is installed it is not customary to heat rooms not occupied and since electric heaters are almost always equipped with three-heat switches the heat can be easily controlled. It is usually more economical to install heaters of ample capacity so that individual rooms can be quickly heated on high heat and maintained on medium or low heat.

When it is necessary to compare electric heaters with steam or hot water radiators, the following table will give fair average comparisons:

1 sq.ft. of steam radiation at 4 lb. pressure	= 70 watts
1 sq.ft. of steam at 10 lb. pressure	= 80 watts
1 sq.ft. of hot water radiation at 180 deg. F.	= 45 watts

Method of Calculating Energy Consumption

The records of the nearest weather bureau will give the hourly temperature for the year. For rough calculations the mean monthly temperatures during each of the heating months over a several-year period may be taken as an average. To estimate the consumption for any month subtract this mean temperature from the desired temperature and divide by the maximum temperature rise figured. Multiply the heater size by this factor and by the number of hours that heat will be required.

As an example, an installation is figured to give 40 deg. F. temperature rise (30 deg. F. to 70 deg. F.) and the mean temperature for a given month is found to be 50 deg. F. The average temperature rise is, then, 20 deg. F. (70 deg. F. — 50 deg. F.). If a 5-kw. heater adequate to give a 40 deg. F. temperature rise was installed in a room and the room was heated daily for eight hours per day, 25 days per month, the consumption would be:

$$5 \text{ (kw.)} \times \frac{20}{40} \text{ (factor)} \times 8 \text{ (hr.)} \times 25 \text{ (days)} = 500 \text{ kw.-hr.}$$

TABLE VII—Typical Operating Costs of Electric Heating—Banks—Air Heating Only

	San Francisco Load 31.8 kw.	Oakland Load 23.6 kw.	Oakland Load 14 kw.	San Francisco Load 10.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	2,970	2,558	1,755	1,613
February	2,670	1,672	1,455	1,321
March	1,350	650	446	635
April	1,710	883	377	1,254
May	870	164	237	404
June	420	219	230	382
July	150	59	117	157
August	120	134	85	301
September	0	62	92	308
October	30	300	98	360
November	600	991	178	725
December	1,230	1,769	653	988
Total for Year	12,120	9,461	5,723	8,448
Average per Month	1,010	788	477	704

The result obtained in this manner would be high, as the mean temperature taken above is the mean for the 24-hr. period and the mean for the heating period would be higher, as it is warmer during the heating hours than the average for both day and night. Allowance must also be made for the sun's heat, which is often a large item.

It is impossible to make an accurate calculation of the monthly consumption of any particular building due to the variations in construction, temperature and heating requirements, but from a close observation of several installations in the San Francisco Bay section, all of which have been installed for some time, and on which very accurate data have been compiled, it has been found that the following are very fair averages:

Typical Energy Consumption

Residences. Consumption per month for six winter months, where a uniform temperature was maintained averaged 20-25 kw.-hr. per kw. of heater capacity installed.

Offices. Consumption per month for six winter months, heating eight hours per day, 26 days per month, averaged 50-60 kw.-hr. per kw. of heater capacity installed.

Schools. Consumption per month for six winter months, heating five hours per day, 20 days per month, averaged 35-40 kw.-hr. per kw. of heater capacity installed.

Do not attempt to compare the operating cost of electric heating systems with those of other heating systems by means of the B.t.u., given off by combustion of other fuels, as it is an unfair comparison due to the fact that the efficiency of other systems can only be estimated, and to the further fact that these comparisons are usually made under ideal conditions, which conditions do not prove normal and correct under actual tests over long operating periods. Furthermore, this efficiency decreases, in fuel operated systems, as plants are operated at less than full load. The only proper comparisons are derived from the results of satisfactory installations.

In determining the actual cost of any heating system the following must be taken into consideration:

1. Interest on initial investment.
2. Insurance on plant.
3. Depreciation of plant.
4. Labor required to operate plant.
5. Repairs necessary to keep plant operating.
6. Cost of fireproof room and necessary flues.
7. Actual cost of fuel.

The flexibility of electric heating systems, which permit heating any room without the need of operating the entire heating plant, also the ease with which the heat may be regulated, must be given careful consideration.

TABLE VIII—Typical Operating Costs of Electric Heating—Churches

	Oakland	Napa	Stege (nr. Richmond)
	30 kw.	15 kw.	27.6 kw.
Air Heating			27.6
Water Heating			5.0
Range			7.5
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,530	990	552
February	890	890	336
March	790	520	384
April	508	440	432
May	240	250	288
June	60	90	216
July	0	10	72
August	10	0	192
September	0	10	96
October	70	50	408
November	520	350	912
December	1,300	680	768
Total for Year	5,918	4,280	4,656
Average per Month	493	357	338

TABLE IX—Typical Operating Costs of Electric Heating—Stores and Offices

	San Francisco 12 kw.	Palo Alto 16 kw.	San Francisco 26.8 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,464	2,158	3,408
February	1,292	1,850	2,448
March	120	804	792
April	210	768	984
May	108	158	168
June	56	0	264
July	34	0	48
August	41	0	288
September	80	0	120
October	80	625	24
November	495	1,178	576
December	878	2,246	1,968
Total for Year	4,858	9,787	11,086
Average per Month	405	815	924

TABLE X—Typical Operating Costs of Electric Heating—Stores and Offices

San Francisco Full Loads	177.9 kw.	12.4 kw.	38.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	23,040	1,516	2,688
February	23,040	820	3,984
March	5,760	731	1,007
April	6,120	522	48
May	3,600	235	96
June	1,680	134	0
July	1,800	9	48
August	2,400	15	0
September	1,200	12	192
October	1,920	53	0
November	3,360	383	144
December	3,960	836	984
Total for Year	77,880	5,266	9,192
Average per Month	6,490	439	766

Ventilation

Although it appears to be a general custom to ventilate rooms from the ceiling or by opening windows this is the most costly and least satisfactory means of ventilation. Hot air, being lighter than cold air, rises and is carried to the outside atmosphere while foul air is heavier than fresh air and falls to the floor level. It is not always a simple matter to ventilate rooms from the floor without mechanical means. The cost, however, is much less by using electric energy to drive an exhaust fan for ventilation than to use heated air to create a draft.

Locations of Heaters

Heaters should generally be placed in such a manner as to cause air currents to move away from windows rather than toward them. Wall or bracket type heaters should be placed only a short distance from the floor. Long or large rooms should be provided with two or more heaters located as far apart as convenient. It is obvious that better heat distribution will be realized from two heaters in a room than from one heater.

Humidity

This is a very important factor in the East and Middle West, where the temperature is often around the zero mark and the percentage of moisture in the air is very low. However, on the Pacific Coast during the heating period the percentage of moisture in the outside air is high, and, as the difference in temperature is not great, the outside air when brought up to room temperature usually contains a sufficient percentage of moisture so that it is not necessary to add to it.

Comparative Operating Costs

The average annual fuel cost in a completely electrified six-room home, as compared to a non-electric home, based on an analysis of several hundred homes in California, is as follows:

Completely Electric

Electric lighting	$ 30.00
Electric cooking	60.00
Electric water heating	70.00
Electric air heating	110.00
Electric refrigeration	20.00
	$290.00

Mixed Fuels

Electric lighting	$ 30.00
Cooking fuel	40.00
Water heating fuel	60.00
Air heating fuel	80.00
Ice	25.00
	$235.00

The difference in cost with complete electric equipment as against other methods will be only $4.00 to $5.00 a month additional, which is more than offset by the advantages enumerated elsewhere.

The average annual cost of furnace oil is from $40.00 to $50.00 per year. Such installations offer some hazard as regards fire and explosion, even when a high grade system is installed. The average cost of such installations in an eight-room home including furnace, oil burner, storage tank, etc., is in the neighborhood of $1,200.00. An electric system for the same house will cost about one-half to two-thirds of this amount. The much smaller cost of electrical installation will offset, for a number of years, the higher operating costs of electric heating. In addition, burners are prone to clog, become fouled with soot, and, due to numerous mechanical auxiliary devices, are subject to considerable depreciation owing to the high temperature in the furnace. The possibility that safety devices will not function at a critical time is ever present. This is particularly true in homes where the equipment is given no attention, expert or otherwise.

Some Data on Energy Used in Existing Installations

Tables IV to X inclusive represent the kw.-hr. consumption of a number of homes, apartments, offices, and banks using electricity exclusively for cooking, water heating, air heating, lighting and appliances.

A Manual on Electric Heating for Schools*

THIS addition to the Manual on Electric Air Heating is intended to furnish specific and reliable information regarding the uses and advantages of electric air heating in schools. The operating data are compiled directly from the monthly billing records of the power company serving the school and are authentic.

The following subjects are treated:

1. Electric heating in California schools.
2. Economy of first cost.
3. Automatic or manual temperature control.
4. Design of electric heater installations.
5. Economy of electric heating for schools.
6. Healthfulness of electric heating.
7. Safety and cleanliness.
8. Ventilation.
9. Actual operating data on typical California schools.
10. Partial list of electrically heated California schools.

Electric Heating in California Schools

Education is today perhaps the most valuable service rendered by the government to its citizens. As this fact has become recognized, so have educational activities been increased. Schools have greatly multiplied and expert planning is applied to their design. Facilities intended to promote the physical comfort, safety, and well being of the children are provided. Great care is given to proper lighting and adequate ventilation. Heating is provided, but until recently has actually been in the form of heating systems

* Further report of subcommittee of electric heating committee, Merchandising Bureau, Commercial Section. E. A. Wilcox, chairman. G. W. Barker, R. C. Bragg, W. W. Hicks, Arthur Kempston, H. E. Mulvaney, Adolph Strauch.

TABLE I—Partial list of electric heater installations in California public and private schools.

School	Location	Approx. Load (Kw.)	Power Company
Aramas Grammar School	Monterey County	61	Coast Counties
Benicia High School	Benicia	216	P.G.&E.
Browns Valley Grammar School	Yuba County	20	P.G.&E.
Colusa High School	Colusa	386	P.G.&E.
Clarksburg Grammar School	Clarksburg	169	G.W.P. Co.
Cora Williams Institute	Berkeley	70	P.G.&E.
Esparto Grammar School	Esparto	199	P.G.&E.
Folsom High School	Folsom	149	P.G.&E.
Geyserville Grammar School	Geyserville	90	P.G.&E.
Hillsborough Grammar School	Hillsborough	31	P.G.&E.
San Benito High School	Hollister	74	Coast Counties
Hughson Grammar School	Turlock	172	P.G.&E.
Kelseyville High School	Kelseyville	87	P.G.&E.
Loomis Grammar School	Loomis	158	P.G.&E.
Pleasant Valley Grammar School	Sonoma County	40	P.G.&E.
Orchard Ward Grammar School	Contra Costa County	32	P.G.&E.
Pacheco Grammar School	Pacheco	30	P.G.&E.
Riverside Grammar School	Sacramento County	44	P.G.&E.
Northbrae Grammar Addition	San Bruno	48	P.G.&E.
Egmont Grammar Addition	San Bruno	52	P.G.&E.
St. Francis Grammar School	Sacramento	197	G.W.P.Co.
Success Academy	San Francisco	14	P.G.&E.
Sunol Grammar School	Sunol	100	P.G.&E.
Tamalpais High School	Marin County	450	P.G.&E.
Tiburon Grammar School	Tiburon	20	P.G.&E.
Wheatland Grammar School	Wheatland	95	P.G.&E.
Walnut Grove Grammar School	Walnut Grove	120	P.G.&E.
Burbank Grammar School	Santa Rosa	25	P.G.&E.
Turlock High School	Turlock	104	P.G.&E.
Robbins Grammar School	Robbins	48	P.G.&E.
Montecito Grammar School	Montecito	183	P.G.&E.
Perkins Grammar School	Perkins	27	P.G.&E.
Carmichael Grammar School		40	P.G.&E.
Courtland Grammar School	Sacramento County	22	P.G.&E.
Sunnyvale High School	Sunnyvale	25	P.G.&E.
Oak Grove Grammar School	Contra Costa County	20	P.G.&E.
Marysville Grammar School	Marysville		
Old River Grammar School	Bakersfield	45	P.G.&E.
Tracy High School	Tracy	50	P.G.&E.
Berryessa Grammar School	Santa Clara County	208	P.G.&E.
John Swett Grammar School	Oakland	58	P.G.&E.
Wilson Elementary School	Sonoma County	24	P.G.&E.
Placer Union High School	Auburn	400	P.G.&E.
Paso Robles Grammar School	Paso Robles	16	P.G.&E.
Fairfield Grammar School	Fairfield	86	P.G.&E.
Richmond Grammar School	Richmond	48	P.G.&E.
Lincoln High School	Richmond	20	P.G.&E.
Sylvan School	No. Sacramento	66	P.G.&E.
Gault School	Santa Cruz	24	Coast Counties
Mountain School	Nr. Soquel	18	Coast Counties
New Jerusalem School (Grammar)	New Jerusalem	68	P.G.&E.
Pittsburg High School	Pittsburg	30	P.G.&E.
Manteca Grammar School	Manteca	146	P.G.&E.
Montecito Grammar School	Montecito	23	P.G.&E.
Marin Junior College	Kentfield	160	P.G.&E.
Lakeport Union High School	Lakeport	23	P.G.&E.
San Mateo Junior College	San Mateo	168	P.G.&E.
Los Olivos Grammar School	Los Olivos	53	P.G.&E.
St. Helena Grammar School	St. Helena	110	G.W.P.
Buena Vista School	Kern County	15	P.G.&E.
Goletz High School	Santa Barbara County	136	P.G.&E.
Lompoc Junior High School	Lompoc	68	P.G.&E.
Lompoc High School	Lompoc	127	P.G.&E.
Grammar School	Nr. Placentia	24	
Mission Grammar School	Soledad	62	
Douglas School for Girls	Pebble Beach	90	P.G.&E.
Palm Avenue Grammar School	Watsonville	210	Coast Counties
Loma Linda Grammar School	Placentia	24	
Montecello Grammar School	Montecello	30	
San Rafael High School	San Rafael	15	P.G.&E.
Vine Hill School	Nr. Martinez	24	P.G.&E.
Alameda Kindergarten	Alameda	30	P.G.&E.
Menlo Boys School	Menlo Park	48	P.G.&E.
Elm Street Primary School	Watsonville	66	Coast Counties
Ridrigues School	Watsonville	100	Coast Counties
Roosevelt Grammar School	Lancaster	60	S.C.E.Co.
Alta Vista School	San Joaquin County	21	P.G.&E.
Encinal School	Coyote		Coast Counties
El Carmelo School	Carmel Valley	12	P.G.&E.
Salinas Jr. College	Salinas	72	P.G.&E.
Rio Vista Grammar School	Rio Vista	55	P.G.&E.
Lagunitas School	Lagunitas		
Piedmont Grammar School	Piedmont		
Capistrano	San Juan Capistrano	128	S.D.Cons.G.&E.
Laguna Beach	Laguna Beach	256	S.C.E.Co.
Simi Valley Grammar School	Simi	42	S.C.E.Co.
San Clemente Grammar School	San Clemente	7	S.D.Cons.G.&E.
Montecito Union Grammar School	Montecito	172	S.C.E.Co.
Goleta Union Grammar School	Goleta	150	S.C.E.Co.
Redman Grammar School	Lancaster	85	S.C.E.Co.
Ojai Valley School	Ojai	134	S.C.E.Co.
Thatcher Boys School	Ojai	93	S.C.E.Co.
San Antonio Grammar School	Ojai	150	S.C.E.Co.
Carlsbad Grammar School	Carlsbad	52	S.D.Cons.G.&E.
Coachella Valley Un. High School	Coachella	37	S.S.P.Co.
Cambria High School	Cambria	28	Mid.Co.P.S.Co.
Dos Palos High School	Dos Palos	76	S.J.L.&P.Corp.
Hughson Grammar School	Turlock	208	Tur.Irrig.Dist.

designed for use in much colder climates than that of California.

The heating problem in California is not that of the Eastern states. Long periods of extremely cold weather demand heating systems capable of raising temperatures anywhere from 50 to 100 deg. and of maintaining these temperatures not only during the school sessions, but overnight as well. In California the heating season is short. Overnight maintainance of temperature is unnecessary and systems of heating having sufficient capacity to raise the room temperature to 68-70 deg. F. in from one to two hours are quite adequate. California school heating requires heating up in the morning, after which the increased outside temperature will make further heating unnecessary with the exception of the few cold rainy days during which continuous heating would be required.

TABLE II—Carlsbad Union School, Carlsbad, San Diego County Calif. Supplied by San Diego Consolidated Gas & Electric Company. Seven classrooms, 52½-kw. heating load.

	1927		1928	
	Kw.-hr.	Bill	Kw.-hr.	Bill
January	2,260	$59.00	1,360	$29.95
February	3,300	85.00	2,510	52.95
March	2,160	56.50	1,880	40.35
April	1,160	31.50	810	18.95
May	370	11.10	550	13.75
June	30		0	
July	0		0	
August	0		0	
September	0		0	
October	0		270	7.50
November	270	7.50	1,140	25.55
December	1,230	27.35	1,280	28.35
		$277.95		$217.35

Economy of First Cost

Installed cost of electric heaters and a proper wiring system is less than that of a steam plant or hot water system, or any other equivalent heating system. There is no cost of maintenance for electric heating. The wiring and the heaters are as permanent as the building. There is nothing to burn out, wear out, rust out, or become clogged up in well designed modern electric heaters. There is no attendant, skilled or otherwise, required for the operation of electric heating; the teacher or pupil controls the temperature in the classroom and does this without reference to the heating required for other rooms. There are no boilers, pumps, motors, burners or mechanical equipment to repair or replace. The original investment provides a life-time of satisfactory service with an absolute **minimum** of maintenance expense.

TABLE III—Coachella Valley Union High School, Coachella, Riverside County, Calif. Supplied by The Southern Sierras Power Co. Nine classrooms, 37-kw. heating load, 21.6-kw. cooking load in Domestic Science Department, 17½-hp. motor load for Manual Training Department, entire current consumption shown.

	1927		1928	
	Kw.-hr.	Bill	Kw.-hr.	Bill
January	4,342	$95.72	4,674	$102.36
February	5,771	124.30	5,268	114.24
March	2,503	58.94	2,525	59.38
April	2,205	41.02	2,229	53.46
May	2,279	54.42	2,059	50.06
June	1,339	34.86	1,638	41.64
July	1,658	33.60	1,546	39.80
August	3,531	68.37	1,342	35.72
September			1,386	32.22
October	1,879	53.70	1,845	41.40
November	2,983	68.54	3,871	81.92
December	4,531	99.50	3,617	76.84
		$732.97		$729.04

(Rate drop, September 9.)

Automatic or Manual Control

Automatic thermostat equipment is now available for room temperature control. These thermostats should preferably be installed to control individual heaters. In this way the interior or shaded portions of a room would be kept warm even though in other portions of the room subject to sunshine the electric heater would be cut off by action of a thermostat. These devices are entirely satisfactory and proved by years of experience. A word of caution, however, regarding thermostatic control—windows, and particularly the upper portion of windows, must not be left open with thermostatic control, as the rapid loss of heat from the upper portion of the room through open windows would require unnecessary current consumption. Excessive ventilation is not necessary with electric heating.

In some cases where heaters are operated manually, a student in each room has been detailed with authority to check temperatures periodically and regulate heaters so as to maintain a uniform temperature of 68 to 70 deg. F.

TABLE IV—Lompoc Jr. High School, Lompoc, Santa Barbara County, Calif. Supplied by Midland Counties Public Service Corporation. Four classrooms, 48-kw. heating load.

	1927	
	Kw.-hr.	Bill
January	2,200	$36.00
February	1,960	32.40
March	1,080	24.00
April	840	24.00
May	480	10.20
June	280	7.20
July	0	
August	0	
September	360	8.40
October	1,000	18.00
November	840	15.60
December	1,400	24.00
		$199.80

All electric heaters, even when equipped with thermostatic control, should be furnished with three-heat switches either built into the heater or arranged for wall mounting at a convenient point. Each heater can thus be operated so as to consume only the current required for the amount of heat needed.

Automatic time control is also valuable inasmuch as it can be set to cut the heat on at any predetermined time in the morning, and cut it off in the afternoon. This will eliminate the necessity of anyone coming to the school in the morning to turn on the heat.

TABLE V—Cambria High School, Cambria, San Luis Obispo County, Calif. Supplied by Midland Counties Public Service Corporation. Six classrooms, 28-kw. heating load.

	1927	
	Kw.-hr.	Bill
January	1,720	$25.66
February	2,080	30.34
March	1,360	20.98
April	880	20.98
May	480	3.30
June	400	8.50
July	0	
August	0	
September	400	14.00
October	360	14.00
November	520	14.00
December	720	14.00
		$165.76

The combination of time and temperature control will not only increase the general satisfaction, but will usually effect greater economy in that it will prevent wasteful use because of excessive temperature and carelessness in leaving heaters on at night. It absolutely eliminates the human element.

General Design of System

It is usually necessary to use two or more heaters to heat the usual standard classroom uniformly and adequately. These should be located at or as near as possible to the coldest point in the room—preferably under windows on the outside walls and/or near a hall door.

Calculations as to heater size should be made to furnish heat required to handle radiation losses as described in another chapter, together with capacity sufficient to heat from two to four air changes per hour depending upon the number of occupants. Capacity should be sufficient to bring temperatures up from lowest inside temperatures attained over week-ends to 70 deg. in not to exceed 2 hours with windows closed.

TABLE VI—Dos Palos High School, Dos Palos, Merced County, Calif. Supplied by San Joaquin Light & Power Corporation. Four Classrooms and Domestic Science Department. 76.5-kw. heating load, 14-kw. water heating, 32.4-kw. cooking load in Domestic Science Department, entire consumption shown.

	1927		1928	
	Kw.-hr.	Bill	Kw.-hr.	Bill
January	7,500	$116.25	11,400	$174.75
February	14,400	219.75	12,100	185.25
March	6,900	107.25	6,200	96.75
April	4,100	65.25	2,300	38.25
May	1,500	26.25	1,900	32.25
June	600	13.92	700	14.25
July		13.92		
August		13.92		
September		13.92	200	7.28
October	900	17.25	2,300	38.25
November	4,500	78.26	7,600	117.75
December	8,600	132.75	8,800	135.75
		$818.69		$840.53

It is much better to so design the system that temperature can be brought up in one hour. Outside temperature conditions and general economics will affect this factor. It is usually difficult to hold infiltration of cold air to less than one air change per hour. Extra ventilation is unnecessary until school room is in actual use. Satisfactory capacities will usually vary from a minimum of two 4-kw. heaters to a maximum of three 8-kw. heaters in standard

TABLE VII—Hughson Grammar School, Turlock, Merced County, Calif. Supplied by Turlock Irrigation District. Sixteen classrooms, 208-kw. heating load, 5-kw. water heater, 36-kw. cooking load.

	1927		1928	
	Kw.-hr.	Bill	Kw.-hr.	Bill
January	13,800	$167.90	14,400	$198.20
February	13,200	162.80	13,800	188.10
March	9,000	127.10	5,900	80.70
April	5,300	45.05	3,000	40.80
May	300	2.55	500	6.80
June	300	2.55		
July				
August				
September			400	5.50
October	600	55.70	1,200	16.20
November	6,200	103.80	9,300	124.00
December	16,200	179.80	10,800	147.35
		$847.25		$807.65

class rooms, depending on weather conditions, type of construction, exposure, size of room, etc.

Having installed sufficient capacity to raise the temperature the required amount in the specified time, it should be remembered that it will not be necessary to operate the heaters at full capacity after the desired temperature has been attained. If automatic thermostatic control is installed, the device will cut down current consumption to the amount needed to maintain temperature. If manual control is being used, it will be necessary to turn the heaters down either to **medium** or **low**, according to the outside temperature. Ordinarily turning the heaters to **low** will be sufficient to maintain the room temperature against ordinary radiation losses, including a reasonable number of air changes. With extremely low outside temperature on very windy days, it may be necessary to operate some or all of the heaters on **medium**. Therefore, in determining approximate operating costs it must be remembered that the heaters are not usually operating on high except during the initial warming up period. The fact that the heaters can satisfactorily maintain room temperatures when turned down to **medium** or **low** is often overlooked when estimating operating costs. Please note that operating hours are not convertible to kilowatt-hours, and must not be so used in making estimates.

In many schools there are office rooms used by the principal, district superintendent or other school officials, which frequently require heat at times other than the school session period. To require a steam heating or similar plant to be operated for this purpose is wasteful. Electric heating is individual to the room. There is no cost of operation other than the current actually consumed in the room being heated. While the direct fuel cost per hour of electric heating is greater than the direct fuel costs of other forms of heating, it must be remembered that the superior flexibility of electric heating provides a definite economy as current is consumed only in the heater being operated and no fuel is wasted in boilers, steam lines or stack losses.

TABLE VIII—Berryessa School, Santa Clara County, Calif. Served by Pacific Gas and Electric Company. Total connected load, 208 kw.

	1927-28	
	Kw.-hr.	Bill
October	600	$55.66
November	2,400	78.47
December	3,800	82.83
January	6,300	100.31
February	4,500	95.89
March	2,700	61.05
April	1,600	74.12
May	1,700	78.47
June	1,400	55.66
July	0	55.66
August	0	55.66
September	0	55.66
October	4,100	221.30
Total for year		$1,070.74
Av. per month		$82.51

TABLE IX—St. Helena Grammar School, St. Helena, Calif. Total connected load, 122 kw.

	1928	
	Kw.-hr.	Bill
January	6,120	$155.25
February	6,120	155.25
March	3,120	64.65
April	2,400	50.25
May	720	16.65
June	60	2.10
July	000†	0.00
August	000†	0.00
September	0	7.10
October	420	54.20
November	2,880*	57.50
December	4,800	60.50
Total for year		$621.80
Av. per month		$51.73

†Not billed. *Increased load, 12 kw.

Economy of Electric Heating

Comparison of operating costs between electric heating and other forms should take into account the following factors:

1. Interest on initial investment (usually 4 to 6 per cent).
2. Insurance on plant.
3. Depreciation on plant (always less with electric heat than with mechanical heat).
4. Labor required to operate plant (much less with electric heat).
5. Necessary repairs to plant (much less with electric heat).
6. Cost of fireproof room and stack.
7. Actual cost of fuel (usually more with electricity than fuel).
8. General satisfaction.
9. Safety from fire and explosion hazard.
10. Increased healthfulness of children.
11. Convenience and flexibility of control.

TABLE X—Benicia High School, Benicia, Calif. Total connected load, 171.3 kw.

	1927		1928†	
	Kw.-hr.	Bill	Kw.-hr.	Bill
December	4,900	$127.40		
January	2,300	59.80	2,200	$61.05*
February	8,400	159.92	4,200	88.30
March	4,300	111.80	2,800	71.72
April	3,100	75.83	1,700	44.20
May	800	50.91	1,700	44.20
June	600	0.00	900	23.40
July	100	0.00	0	47.29*
August	0	0.00	0	51.43*
September	100	44.95*	300	51.43*
October	300	50.91*	400	51.43*
November	0	0.00	1,800	52.35
December	4,000	113.40	3,000	82.83
Total		$794.92		$669.63
Av. per month		$56.78		$55.80

*Minimum
†Load increased to 174.1 kw.

If this is done, the cost of electric heating will compare most favorably with other forms of **equivalent** heating.

It is well understood now that electric heating is healthful heating. The air of a room where electric heating is used is simply raised in temperature. No chemical or other change occurs in the air. The air is not vitiated or destroyed either by the generation and discharge of noxious fumes or by the combustion of oxygen. There is no moisture of combustion because there is no combustion.

Ventilation is not interfered with when electric heating is used. When window ventilation is used or a fan or blower system is installed, electric heating operates with entire satisfaction because, as previously stated, it simply raises the temperature of the air in the room. Healthfulness should be stressed **especially** in schools.

TABLE XI—Loomis Union Grammar School, Loomis, Calif. Total connected load, 166.6-kw.

Month	Max. Demand	Kw.-hr.	Energy Charge	Demand Charge Min.	Bill
October—1926	40.2	60	$1.86	$50.00	$50.00
November	32.2	480	14.88	50.00	50.00
December	104.6	4,680	107.64	85.49	85.49
January—1927	127.9	7,680	166.37	100.64	105.26
February	128.7	10,740	212.59	101.16	212.59
March	124.7	6,660	149.79	98.56	149.79
April	120.6	6,600	147.24	95.89	147.24
May	84.5	1,080	28.08	72.43	28.08
June	72.4	720	18.72	64.56	18.72
July	16.1	60	2.16	50.00	2.16
August	0	0	0	50.00	0
September	0	0	0	50.00	19.40
Totals	38,760		$849.33	$868.73	$868.73
October	0	0	0	50.00	50.00
November	41.8	780	20.28	50.00	50.00
December	112.6	5,760	131.44	90.69	90.69
January—1928	152.8	10,320	215.92	116.82	176.95
February	146.4	14,580	277.28	112.66	277.26
March	144.8	10,620	217.22	111.62	217.22
April	104.6	6,360	137.24	85.49	137.24
May	84.5	3,300	85.80	72.43	85.80
June	72.4	900	23.40	64.56	23.40
July	50.00	120	3.12	50.00	3.12
Totals		52,740	$1,111.68	$804.27	$1,111.78
Av. per month		2,397	$50.53	$36.50	$50.53

Safety and Cleanliness

Electric heaters are now available for school use which are so designed that there is no possibility of accidental contact by children or others with live parts. The fire hazard is greatly minimized. Temperatures are well below the ignition point of cloth fabrics, so that even if garments come in contact with exposed parts, there would be no danger from fire. These heaters are likewise designed to operate at maximum efficiency so that all the electric current consumed will be used for producing heat. Only such heaters as have been fully approved by the underwriters' laboratories should be used in any instance.

There is no smoke, soot, dirt, moisture or disagreeable odor from electric heating. There are no coal bins, ash pits, or oil tanks; and there is absolutely no danger to persons or property from explosion, asphyxiation or poison from products of combustion.

TABLE XII—Esparto Union High School, Esparto, Calif. Connected load, 180 hp.

	Kw.-hr.	Energy Charge	Minimum	Bill
November—1925	2,480	$57.04	$97.65	$97.65
December	8,240	177.20	104.60	136.59
January—1926	9,200	183.04	90.69	183.04
February	13,840	254.23	101.16	254.23
March	7,520	160.00	94.20	160.00
April	2,080	54.08	69.76	54.08
May	640	16.64	52.60	16.64
June	320	8.32	52.60	8.32
July	80	2.08	52.60	2.08
August			52.60	
September			52.60	
October	960	24.96	66.32	24.96
November	2,160	62.81	56.16	62.81
December	9,680	192.40	82.20	192.40
January—1927	9,360	191.89	101.16	191.89
February	16,000	280.70	104.67	280.70
March	13,920	259.90	104.67	259.90
April	8,320	178.45	104.67	178.45
May	2,560	58.88	83.74	58.88
June	720	18.72	52.60	18.72
July			52.60	
August			52.60	
September			52.60	
October	800	20.80	52.60	20.80

Ventilation

Ventilation is one point in schools that is usually abused. Excessive ventilation has been talked by fresh air enthusiasts until all kinds of excessive and unnecessary fresh air is used. Wasting heat is no advantage. Every school job should be carefully coached to get correct ventilation without waste.

Actual Operating Data in California Schools

The accompanying eleven tables give records of current consumption and cost of some characteristic electrically heated schools showing actual power-company records of some of the many schools so equipped.

Appliance Merchandising*

THE appliance committee reports definite results toward the accomplishment of the following four major objectives which it adopted at the beginning of the year.

Red Seal Activity: A more concerted effort on the part of the industry for more Red Seal homes and installation of more convenience outlets, this to be amplified by closer co-operation through building contractors and architects.

In connection with this objective the committee has authorized printing and distributing of 1,000 embossed easel cards bearing the imprint of a convenience outlet. These cards are being distributed throughout the industry, particularly to central station companies and dealers, and are to be placed on sales counters with some appliance always plugged into them.

Appliance Advertising With Particular Reference to the Convenience Outlet: The committee has co-operated with and taken advantage of a decided trend toward this type of publicity which has been manifested by newspaper, radio and direct mail advertising on the

* Report of appliance committee, Merchandising Bureau, Commercial Section. Myron McNeal, general chairman.

part of all four branches of the industry. This has been supplemented by personal field sales effort.

Window and Store Display: Regular window and store display departments have been organized by many of the power companies. Activity along this line has increased dealer interest. Through the discussions which developed in Appliance Committee conclaves the display work of companies represented has been encouraged.

Stimulation of Employee Activity in Merchandise Selling: Employee participation in direct appliance selling during the last year has shown a decided upward trend. This committee has directed its efforts towards the furtherance of this activity.

In addition to these four major objectives the following suggestions were developed during committee meetings.

It is recommended that a tag bearing a picture of a twin convenience outlet be attached to all appliances by manufacturers, this tag to point out the added advantages of the use of the appliance with the convenience outlet. In the interest of the development of this convenience outlet it is our recommendation that the term "lamp socket appliance" be abolished.

The committee has appointed a subcommittee called the New Lines Committee. Its duty is to keep the industry advised of new types of appliances having good merchandising possibilities.

Simplified Electric Range Wiring Standards*

THE range committee this year has had as an objective a survey of the territory served by member companies to determine to what extent the simplified range wiring plan has been accepted and approved by the various communities.

This survey has covered a total of 140 communities with the following results:

Plan approved by	103
Approved, with reservations	9
Not approved	11
No report	17

* Report of electric range committee, Merchandising Bureau, Commercial Section. R. W. Turnbull, chairman. O. R. Doerr, M. G. Pfyl, P. H. Booth, C. H. Paulin, M. S. Hennoch, R. W. Kimberlin, J. H. Mead, E. F. Perkins, J. W. Wrenn, L. F. Galbraith, R. E. Tompkins, Robert McDonald, O. S. Clifford, A. M. Frost, Ward Shafer, George Bigelow, E. W. Meise, P. S. George.

The reservations made by some of the inspectors have been due to their reluctance to accept the recommendation for the use of three No. 6 wires in a 1-in. conduit, but it is understood that the new National Code will incorporate changes including approval of this, which will be accepted by these local inspectors, and on this basis the plan will be approved by them.

The further objective of the committee has been the gathering of more recent data concerning the demand and diversity in apartment house installations of electric ranges, water heaters, air heaters, and refrigeration, but this survey to date has been somewhat unsatisfactory, due to the wide variation of installations.

The use of electric ranges and refrigerators has quite generally been accepted throughout the territory as a desirable feature in apartment houses, and builders, investors and owners are rapidly coming to the point of recognizing the absolute necessity of this electrical equipment in order to have their buildings considered as being strictly modern.

The following are extracts from reports of some member companies:

In the City of Los Angeles, the diversity in demand on apartment house range installations is considered as follows:

1. Installation of electric ranges only 10 per cent
2. Installation of electric ranges and air heaters 40 per cent

The records covering the installation of electric ranges and air heaters with electric water heaters are not sufficiently definite to give any figures on such equipment.

From the San Joaquin Light & Power Corporation system, a report of 17 electrically equipped apartment houses with a total of 75 apartments, shows the following:

Ranges	74
Water Heaters	46
Air Heaters	31
Average connected load	8.7 kw.
Average monthly kw.-hr. consumption	177
Average monthly bill	$6.90

Because no demand meters have been used on apartment house service, we cannot give accurate figures on actual demand, but the following factors used in calculating transformer capacity will be interesting. These are based on actual kilowatts of installed capacity in ranges and water heaters.

For one consumer we install, in transformer capacity, 60 per cent of the range and water heater connected load.

For two or three consumers	40 per cent
Four to six consumers	30 per cent
Six to eight consumers	20 per cent
Over eight consumers	15 per cent

If air heaters are installed in the apartment, we add 75 per cent of the total air heating connected load, and for small motor loads, if there are any, we add 100 per cent.

Southern California Apartment House Electrification Statistics.

Location	No. of Apts.	Range	Water Heaters	Air Heaters	Con. Load Kw.	Maximum Demand	Average Monthly Kw.-hr. per Apt.	Refrigerators Installed No.	Type
Los Angeles	10	10			52.0		96	10	Indv.
Long Beach	2	2	1		22.8	13.7	150		
Long Beach	2	2	1		18.0	10.8	50		
Long Beach	82	80			552.0			82	Mult.
Long Beach	10	10		20	111.0		112		
Uplands	7	7			42.0		113	7	Mult.
Eagle Rock	12	12		36	160.0	75	120	12	Indv.
Porterville	4	4	1	4	37.2		677		
Porterville	4	4	1		30.2		398		
Porterville	2	2	1	2	22.0		402		
Redlands	8	8	8	8	88.0		153		
Beaumont	5	5	1		41.0		115		
Hermosa	5	5	1		42.0		134	5	Indv.
Santa Barbara	25	25		25	75.0		127		
Santa Monica	20	20			150.0		240	20	Indv.
Beverly Hills	84	84			589.0	500	200		Mult.
Hollywood	12	12		12	150.0		275		Mult.
Hollywood	12	12			90.0				
Tulare	6	6	6		57.6		390		
Tulare	4	4	4		42.0		347		Mult.
Tulare	2	2			12.5		160		
Tulare	5	5	1		40.5		365		
San Joaquin	75	74	46	31	652.5		177		
Los Angeles	54	39		135	531.0				Mult.
Los Angeles	85	85		285	510.0				Mult.
Los Angeles	50	50		198	679.0				Mult.
Los Angeles	153	153		5	855.0				Mult.

A tabulation of apartment house installations in Southern California accompanies this report in which it will be noted that a wide difference in current consumption is shown between the different installations, which is due largely to different types of apartment houses and the variable conditions under which these installations have been made.

In the discussion of electric range sales department activities, the committee recommends that the following sales helps be developed and given further consideration:

1. Greater executive interest in sales department activities.
2. More extensive use of electric ranges by everyone connected with the industry.
3. The development of a better understanding of merchandising problems on the part of the employees other than the sales department.

It is also recommended that the range committee next year devote its entire energies toward the development of practical sales producing plans, and the dissemination of such information to the sales departments of the member companies.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

POWER AND HEATING BUREAU REPORTS[2]

Developments in Industrial Electric Heating*

The work assigned to the industrial heating committee for this year was divided into four sections, and each of these parts has been followed to its conclusion.

First, was the revision of the Industrial Heating Handbook consisting of adding to it a number of photographs of new installations, removal of obsolete data and revision of certain sections. This book is now up-to-date and should prove a valuable sales aid.

Second, was the compilation of a treatise on oil pipe line heating and we are now able to report that the results of the investigation are compiled and will be released for publication.

Third, encouragement of attendance at the Industrial Heating School to be held in Cleveland in May has been successful and it is expected that at least five men will attend from the Pacific Coast Electrical Association territory.

Fourth, we wish to report successful participation in the Western States Metal and Machinery Exposition held in Los Angeles in January, 1929. One afternoon consisted of a joint session of the American Society of Steel Treating and the Pacific Coast Electrical Association at the exposition, on the use of electric heat in industry. Showings of the N.E.L.A. industrial heating film were made throughout the exposition. There were many operating displays of electric heating apparatus which led to the discovery of a number of prospects.

This committee has been of assistance in the development and promotion of industrial electric heat on the Pacific Coast and the report is amended with data indicating the trend of this load and sources from which it comes.

ASSIGNMENTS of this committee for the year were as follows:

1. Revision of the Industrial Heating handbook.
2. Preparation of a report on oil pipe line heating.
3. Encourage attendance at the Industrial Heating School to be held in Cleveland in May, 1929.
4. Participation in Western States Metal and Machinery Exposition held in Los Angeles in January.

Revision of Industrial Heating Handbook

The industrial heating handbook has been of great assistance to salesmen and specialists who are intimately connected with the promotion and development of electric heat in industry. Through its use it is possible to show a prospect photographs and operating data of equipment applicable to the processes in his industry. There are 22 of these in the possession of member companies of this organization.

Five sets of photographs were removed from the book because the equipment had become obsolete. Three of these were of automobile enamel baking ovens which had become obsolete because of the use of Duco instead of baked enamel. One was of an oven which had proven so successful that it was replaced by a larger unit. Another photograph was of an early experimental type walnut dehydrator which has not been successful in its operation. However, there are several photographs of successful walnut dehydrators remaining in the book. A number of obsolete manufacturers' catalog and booklets were removed.

Revision was made of two lists of equipment in use, one of electric arc furnace installations on the

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[2] **P. P. Pine,** San Diego Consolidated Gas & Electric Company, chairman. **E. G. Stahl,** San Joaquin Light & Power Corporation, vice-chairman. **Central Arizona Light & Power Company:** C. T. Yates. **Coast Counties Gas & Electric Company:** F. D. Beardsley. **Everhot Manufacturing Company:** H. H. Fogwell. **General Electric Company:** F. E. Boyd, Loys Griswold, E. M. Ellis, M. Rhine, E. J. Cipperly, C. R. Owens. **Great Western Power Company of California:** H. E. Brillhardt, G. W. Bernhard, L. D. Sherman. **Midland Counties Public Service Corporation:** A. D. Church. **Los Angeles Bureau of Power & Light:** C. H. Dye, E. V. Kane. **Pacific Gas and Electric Company:** T. A. Wood, Noel Pike, J. L. Farley. **San Joaquin Light & Power Corporation:** M. P. Lohse. **Southern California Edison Company:** F. L. Allen, H. V. Busby, G. N. Hawley, R. C. McFadden. **The Southern Sierras Power Company:** D. B. Wheelock, W. R. Chawner. **E. A. Wilcox Company:** E. A. Wilcox. **Wesix Electric Heater Company:** Adolph Strauch. **Westinghouse Electric & Manufacturing Company:** F. E. Anderson, H. D. Easterbrook, Daniel Zinck. **University of California:** B. D. Moses (Davis, Calif.).

* Report of industrial heating committee, Power and Heating Bureau, Commercial Section. R. C. McFadden, chairman. G. W. Bernard, E. J. Cipperly, H. H. Fogwell, J. F. Farley, G. N. Hawley, E. Z. Kane, M. P. Lohse, C. R. Owens, Adolph Strauch, E. A. Wilcox, Daniel Zinck.

Pacific Coast and the other of all of the plants in the country using electric heat for vitreous enameling.

Thirty-eight photographs and data sheets of Pacific Coast installations were added. These covered the field in general showing arc melting, core baking, brass melting, vitreous enameling, enamel baking and heat treating. The total number of new prints required was eight hundred and thirty-six.

We wish to express our appreciation to the General Electric Company for furnishing 21 of these, the E. A. Wilcox Company for furnishing four and to the James H. Knapp Company for providing four. The remaining pictures were taken under the direction of this committee.

The committee is attempting to make this handbook essentially a book of pictures, with operating data attached, for installations on the Pacific Coast. Eastern installations are being eliminated as rapidly as possible because the effectiveness of the book will be greater in showing that which we have right here at home.

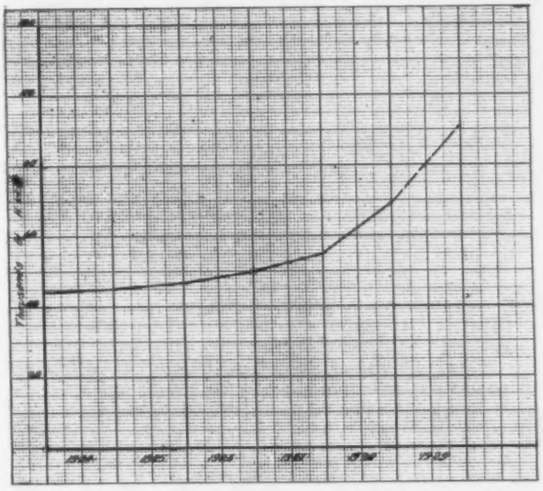

Fig. 1. Curve showing growth of total connected industrial electric heating load in P.C.E.A. territory.

The work of revision was placed in the hands of a sub-committee consisting of E. J. Cipperly and George N. Hawley.

Report on Oil Pipe Line Heating

Research on oil pipe line heating by electricity has been done jointly by the General Electric Company and the San Joaquin Light & Power Corporation. The results of this research and investigation have been compiled into one of the most comprehensive reports on this subject that has ever been prepared, and the original report, in a slightly revised form, is now available for publication, and copies will be supplied to those interested. It is appropriate at this time to place full credit for this report with C. R. Owen of the General Electric Company and M. P. Lohse of the San Joaquin Light & Power Corporation.

Promotion of Attendance at Industrial Heating School

Surveys have shown that the value of industrial heating to central stations is of an almost unbelievable magnitude and we realize that the surface has just been scratched. Any assistance which will help obtain this large load and hold it should be accepted.

Industrial heating covers a very wide field and to understand its successful application it is necessary to be acquainted with a number of industrial processes, each of which may be enormous in itself. Then too, this business is new, equipment is being developed at a rapid pace and it is no small job to keep in step with all of the essential new things. It must be admitted that there is much to be known to sell electric heat successfully.

This committee, because of its close association with heating, realizes this better perhaps, than do others, and for that reason assumed the task of promoting attendance at the industrial heating school. This school is to be held in Cleveland from May 14 to May 24, inclusive, this year.

There will be twenty-seven hours of classes held at the Case School of Applied Science, Cleveland, and the latter part of the course at the Detroit Edison Company in Detroit. The class room work will be supplemented by two full day inspection trips and six half-day trips. The school will be broader in its scope this year than ever before.

From information which we now have at least five men from P.C.E.A. territory will attend and we believe that this will be the greatest attendance ever from this section.

The Western States Metal and Machinery Exposition

The Western States metal and machinery exposition was held in Los Angeles at the Shrine Auditorium, Jan. 14 to 18 inclusive, 1929. It was a part of this committee's work to participate in this exposition because of the value which would result from contact with those who use heat in the manufacture of their product.

A program was presented by the Commercial Section of the P.C.E.A. at the exposition as a regular meeting of both organizations. This meeting was held in the Shrine Auditorium at 2 P.M. on Jan. 17, 1929. The attendance at the meeting was approximately 200.

The N.E.L.A. industrial heating film was shown twice daily throughout the entire exposition and was at no time lacking interested attendance.

The many displays of electric heating equipment most of which were in operation was an important factor in helping put the story across.

The E. A. Wilcox Company had the following equipment in actual operation: Hagen box type heat treating furnace, Ajax high frequency furnace, Young Bros. enamel-baking oven, babbitt melting pot and a Taylor-Winfield spot welder.

A rivet heater and a bar heater were operating at the booth of the American Can and Foundry Company.

The Westinghouse Electric & Manufacturing Company had a small electric furnace and an automatic welder, both operating, on display.

The General Electric Company had a large box type furnace in full operation. In addition two arc welding sets were on display.

A forging and high speed steel treating furnace was operated by the Carborundum Company. An exhibition Glo-bar furnace was also operating.

The Leeds-Northup Company was operating a hump furnace and a homo furnace.

The Knapp Company was operating a Westinghouse salt pot furnace.

An interesting display was that of the West Coast Pipe and Steel Company where pipe was being made by the use of an automatic welder.

The following companies had arc welders on display, some of which were in operation: Lincoln Electric Company, Schrader Welder Manufacturing Company, Federal Spot Welder Company, Wilson Welders and Metal Company, and the Fusion Welding Company.

It is interesting to note that steel companies using electricity in their process made mention of the fact in their displays. The following are the companies represented at the exposition who make and advertised electric steel: Colonial Steel Company, Crucible Steel Company, Finth Sterling Steel Company, Halcomb Steel Company, and the Simonds Saw and Steel Company.

The booth of the Southern California Edison Company was devoted entirely to advertising of electric heat and had a display of the various products manufactured under their lines on which electric heat had been used. The products displayed were decidedly of a diversified nature coming from twenty-five factories. There were oil well tools which had been heat treated, a switch box on which the enamel had been baked by electricity, a phonograph record, the wax of which was heated electrically, dishes which had been decorated by the use of electric heat and other products, all of which went to make up a most interesting exhibit. A photograph of the booth is included in this report.

The manufacturers who had displays at the exposition and whose products were shown at the Southern California Edison Company exhibit, had this sign in their booth "Electric Heat Helps to Make These Products Better."

The total attendance at the exposition was approximately 51,000.

A number of prospects for electric heating were discovered and we feel that the exposition was well worth the effort spent in advertising the fact that we have electric heat for sale.

Conclusion

The committee believes that the revision of the handbook should be continually an objective of this committee in order that it may keep up with the latest. At the present time the book is in excellent condition.

This committee should aid and assist to the best of its ability any plans which will help sell electric heat. The Industrial Heating Schools are decidedly worth while and it is recommended that the promotion of attendance at these annual schools be an accepted function of this committee.

The results of our participation in the Exposition were most gratifying and we urge similar participation in such activities to any of the sections of the N.E.L.A. in whose territory similar expositions are held.

The duty of this committee in the broader sense is the promotion of electric heat in industry. We feel that this committee of past years and the year which has just ended has done considerable toward the achievements of the total results obtained.

The members of this committee are those whose job it is to promote electric heat for the organization with which they are affiliated.

During the year of 1928 the member companies of the P.C.E.A. secured approximately 15,250 kw. in electric heat. When it is remembered that this business will average about thirty dollars per kw. per year we may translate this figure into a sum of approximately $460,000. This is significant of the value of this load to the central station and this almost half million dollar revenue represents the return for one year from the new business obtained in 1928.

This business is of a most diversified nature and the following shows the sources of this 15,250 kw.:

Application	Kw.
Heat treating	2,600
Arc welding	2,475
Steel melting	1,725
Citrus room heating	1,500
Incubators and brooders	900
Glass annealing	835
Dairy sterilizers	790
Japanning and enameling	540
Spot welding	485
Alloy melting	410
Core baking	400
Solution tank heating	200
Mattress sterilizing	190
Walnut dehydration	190
Armature baking	175
Linotype metal melting	175
Oil heating	125
Insectary heating	93
Fish drying	65
Medical sterilizers	60
Wax melting	55
China decorating	22
Miscellaneous	1,240
Total	15,250

As mentioned above, 1928 was almost a half million dollar year and it is interesting to observe the trend of this load. At the beginning of 1927 there were approximately 49,750 kw. of industrial heating on the lines of the member companies of the P.C.E.A. During 1927 approximately 4,450 kw. were added, during 1928, 15,250 kw. and from estimates which have been made there will be approximately 22,250 kw. in 1929. That this load is on the upward trend is better illustrated by the accompanying graph.

It is seen that a million dollar year is not far away and by proper salesmanship, intensive development and constructive promotion this load will become one of the great sources of revenue.

Fig. 2. Southern California Edison Company's exhibit at the Western States Metal & Machinery Exposition at Los Angeles.

Engineering Section[1]

ACCIDENT PREVENTION COMMITTEE REPORTS[2]

Radio Aerials and Power Line Hazards*

EVER-INCREASING numbers of radio aerials being installed at receiving stations caused an investigation to be made to determine what could be done to eliminate accidents caused by aerials coming into contact with power lines. A very large percentage of homes possess radio sets and their use is spreading.

Hazards involved in the use of the radio, as measured by the ratio of the number of accidents to the number of persons participating in the use of radio, are very small. The benefits derived from and the number of lives saved by its use more than offsets the accidents caused by the radio and its supplementary equipment such as aerials. However, a review of some typical examples of accidents shows that such accidents as do occur could be greatly reduced if proper precautions are taken, if safer methods were used when installing receiving sets, and if proper educational work were done.

The greatest danger in connection with radio and the cause of the majority of serious accidents is in thoughtlessness and ignorance in the erection of aerials. The results of such carelessness or individual ignorance properly should not be charged to radio but rather to those responsible for placing the equipment at the hands of those unfamiliar with its use, and the latter's ignorance of electricity. Several examples of accidents caused in the erection of aerials are mentioned.

Mr. "J." standing on the front porch of his home and somewhat elevated above the street level, decided to attach one end of his aerial to a tall tree across the street. Apparently disregarding the power wires which were at about the same level as himself above the roadway he threw his aerial wire out over the power wires toward the tall tree. Being on a dry porch and fairly well insulated from the ground he received no shock until he ran down to the road and jumped up to catch the end of the aerial which he had thrown out over the wires. When he reached the wire to start pulling the slack out of it, he received the shock which proved fatal. It so happened that the weatherproofing on the power wires was sufficient to prevent shorting between phases until he took strain on the aerial wire when standing on the roadway.

Mr. "M" employed by Mr. "R" was helping the latter install a new antenna. A single-phase 2.3-kv. line ran along the front of the property on which they were working and another line ran at a 45-deg. angle across the property. The men in erecting the two aerial poles which were each about 30 ft. high attempted to throw a guy wire for one of the poles over the clothes line and in so doing caused the guy wire to contact the power line. This resulted in a fatal accident to Mr. "M."

Mr. "R.," a lad of 15 years, climbed up a power transmission pole (on which was located an 11-kv. circuit, a 4-kv. circuit and a secondary circuit) to attach an aerial wire. When he stood on the 4-kv. crossarm and threw the end of his aerial wire toward the house in which he lived it came in contact with the higher voltage line first, then fell down contacting the others and burning them down. The lad was severely burned and his clothes set afire but he clung to the pole until removed by rescuers. The burns later proved fatal. It should be mentioned that the lad was warned not to climb the pole, but climbed anyway.

These three examples are sufficient to show that the nature of the hazards in connection with this subject although few in number are very serious. Each could have been avoided if handled by one properly instructed in regard to such dangers.

In almost any city today one may find a large number of radio aerials installed in the most slipshod manner above roofs of private dwellings, flats, etc. with utter disregard for public safety, and in close proximity to power lines. Installed with very small and insecure poles with very small wire for antenna, these wires are broken by wind and carried along like a cotton string into adjacent power lines on a level or below the roofs of buildings.

This brings to attention the importance of proper contact with the public, particularly on matters of this nature. If any hazards are involved they should be explained to the parties concerned and at the same time a man experienced in power line work should remove the aerial in question for the party, with instructions as to the proper method for installing it. It should not be left to the party to remove an aerial found to be a hazard to power lines, since a serious accident may occur when such aerial is being removed. The reaction of the public is favorable when the dangers involved in this subject are handled correctly as a public-relations matter, and when it is explained from a safety point of view.

A number of cities have ordinances covering the construction and installation of radio aerials, but they are not uniform with respect to each other nor are many of them enforced. The departments of electricity in most cities pass a rather rigid inspection on house wiring and manufacturing-plant power installations, but little is being done to curtail the increasing radio aerial hazards. The National Safety Council has valuable information put out in pamphlets on the subject of radio and radio hazards. The National Board of Fire Underwriters has certain general rules governing antennas with respect to fire hazards. It seems, however, that there is no one particular source of instruction or set of regulations directed far enough to reach the ones who are creating the hazards.

Suggested Aerial Code

It may be suggested that a standard code be agreed upon and adopted by all organizations concerned and a method for the enforcement of certain rules be obtained. Valuable assistance in the latter could be had through the various radio trades associations,

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[1] Executive committee—N. B. Hinson, chairman. F. R. George, vice-chairman. J. O. Binney, H. H. Buell, A. W. Copley, R. R. Cowles, E. A. Crellin, C. S. Gilcrest, R. H. Halpenny, A. G. Jones, J. A. Koontz, Jr., W. H. Lindblad, H. H. Minor, E. R. Northmore, F. G. Philo, W. E. Row, W. H. Talbott, W. R. Van Bokkelen.

[2] **F. S. Thomas,** Coast Counties Gas & Electric Company, chairman. **J. R. Rowe,** Los Angeles Gas & Electric Corporation, vice-chairman. **San Diego Consolidated Gas & Electric Company:** W. E. Richmond. **Los Angeles Bureau of Power & Light:** W. L. Smith. **Los Angeles Gas and Electric Corporation:** Vernon Taylor. **San Joaquin Light & Power Corporation:** J. M. Buswell. **Southern California Edison Company:** D. G. Macey, W. E. Row. **The Southern Sierras Power Company:** M. S. Slaughter. **Pacific Gas and Electric Company:** S. C. Dickinson, S. G. Olson.

* Report prepared for accident prevention committee, Engineering Section, by S. T. Olson.

county dealers associations and radio retailers associations, chiefly by educational means.

The following rules if placed in the hands of the radio "Fan" would go far toward eliminating accidents:

(A) Don't attach an aerial to a telegraph, telephone or electric light pole.

(B) Don't string an aerial over railroad tracks or public highway, or over telephone or power wires.

(C) Don't throw an aerial wire over an electric light wire, power wire, or telephone wire to make it reach a support on the other side.

(D) Don't attach an aerial to an insecure support.

(E) Don't attach an aerial to a tree unless provision is made for swaying of the tree. This may be done by using a phosphor bronze spring or a counter weight suspended through a pulley.

(F) Don't use wire smaller than No. 14 copper or No. 17 bronze or copper-covered steel for an outdoor aerial.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

ELECTRICAL APPARATUS COMMITTEE REPORTS[2]

Automatic Substations*

This report covers briefly the subject of the utility of automatic substation equipment, particularly as applied to a.c. substations and to ac./d.c. substations for railway service. The report is presented in several parts.

A general outline of the work and findings of this committee is given in the first part together with a listing of certain automatic and semi-automatic stations. The second part covers some of the recent developments and applications of automatic and semi-automatic equipment as reported by two major electrical manufacturers. Certain typical stations now in service are described briefly by representatives of the various companies operating them. The purpose of this is to point out to those less familiar with this equipment the methods of application of this equipment with a view to stimulating a more general use of it. If this can be brought about, it is the opinion of the committee that greater economies can be effected in the distribution of electrical energy.

To this end attention is directed to the reliability of certain installations as shown by operating records. Attention also is directed to improvements that manufacturers constantly are making.

THE 1928-29 subcommittee on automatic substations was made up of a member from each of the power companies and two from the leading manufacturers of electrical apparatus. The purpose of this committee was to make a study of the different types of automatic substations that are being used and to point out the conditions, as nearly as possible, that influence decision in selecting one type of station over another. The committee has largely avoided detailed description of the apparatus as it is thought that that phase of the subject was covered thoroughly in the serial report of the 1927-28 N.E.L.A. electrical apparatus committee. However, some details of more recent development have been included.

In order to get a complete picture, an outline was sent to each of the committee members suggesting the various types of substations on which to report. This outline suggested a study for a.c. substations, automatic reclosing equipment, supervisory control, metering by the supervisory principle, and also various combinations of the a.c.-to-d.c. railway substations, both in the rotatinig type of station and the mercury-arc rectifying stations.

In this study it was found that there are in use three general types of automatic substations: (1) a.c. feeder type (2) a.c.-to-d.c. with rotating machinery and (3) a.c.-to-d.c. with mercury-arc rectifiers.

The first of these may be divided into subdivisions representing full automatic unattended stations, partially automatic stations with attendant, and non-automatic stations designed for reclosing with supervisory control. The former is used in outlying districts where consumers are small and widely distributed and the latter two where service is the chief point to be gained. Recent installation of a.c.-to-d.c. railway stations with either rotating or mercury-arc rectifying equipment are nearly all fully automatic.

Conclusions

In general, where automatic equipment is involved, the design as to whether the equipment should be semi-automatic, fully automatic, attended or non-attended is largely a matter of size, importance, and specific operating condition. The expense always is to be considered, but as the demand for automatic equipment increases and the development charges are paid off, there is no doubt that more and more automatic stations will be installed. This applies equally to the supervisory indication and control method and to remote load indication.

As far as the reliability of the automatic apparatus

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[2] **H. T. Sutcliffe,** Pacific Gas and Electric Company, chairman. **H. L. Sampson,** Southern California Edison Company, vice-chairman. **Coast Counties Gas & Electric Company:** W. R. Van Bokkelen, A. E. Strong. **Great Western Power Company of California:** C. F. Benham, G. K. Morrison, A. Scott. **Los Angeles Gas & Electric Corporation:** L. A. Buese, J. G. Rollow, C. B. Judson, G. M. Babcock, C. Pettingill. **Pacific Gas and Electric Company:** H. S. Lane, H. A. Laidlaw, S. J. Lisberger, J. P. Jollyman, N. P. Carlsen, Jr., B. D. Dexter, R. B. Kellogg, C. W. Smith, B. N. Merritt, C. J. Kirtley, T. W. Snell. **San Diego Consolidated Gas & Electric Company:** K. B. Ayres, D. J. Kelly, A. S. Glasgow. **San Joaquin Light & Power Corporation:** E. W. Otto, C. E. Schnell, R. C. Tenny, R. D. Likely, P. C. McCorkle, E. J. Crawford. **Southern California Edison Company:** J. C. Gaylord, A. P. Sessions, E. R. Stauffacher, F. H. Mayer, R. H. Cates, E. W. Rockwell, C. W. White, J. D. Enerfer. **The Southern Sierras Power Company:** Francis Curtis, R. H. Halpenny, Frank Ayres, M. L. Baden, J. N. Keith. **Los Angeles Bureau of Power & Light:** J. C. Albert, H. H. Cox, Oscar Wingard, Roy Martindale, O. W. Holden. **City of San Francisco:** P. J. Ost. **Allis Chalmers Manufacturing Company:** F. H. Searight. **Farnham & Cunningham:** R. E. Cunningham. **Garland-Affolter Engineering Company:** P. H. Affolter. **General Electric Company:** J. C. Porter, Fred Garrison, H. E. Fuqua, J. S. Spurck, M. S. Barnes, A. Fulton, W. C. Smith, J. F. Spease, H. C. Stanley, R. F. Monges. **C. E. Ingalls, Inc.:** C. E. Ingalls. **Kelman Electric & Manufacturing Company:** E. K. Sadler. **Pacific Electric Manufacturing Corporation:** Roy Wilkins, E. F. Sixtus. **H. B. Squires Company:** S. P. Russell. **Westinghouse Electric & Manufacturing Company:** W. L. Winter, J. E. Bridges, A. W. Copley, P. B. Garrett, W. P. L'Hommedieu, David Hall, R. A. Hopkins, R. C. Stackhouse. **United States Motor Company:** T. G. Myers. **H. M. Thomas Company:** H. M. Thomas.

* Report of automatic substations subcommittee of electrical apparatus committee, Engineering Section. F. H. Mayer, chairman. L. A. Buese, Francis Curtis, R. B. Kellogg, H. C. Stanley, Oscar Wingard, P. B. Garrett, A. S. Glasgow, E. W. Otto.

is concerned, there is no doubt but that confidence has been created based upon past experience. Much of the equipment has been standardized and recent design of automatic equipment has introduced simplicity without sacrificing reliability, a great advantage from a maintenance standpoint.

The chief question of importance which induces hesitation on the part of the company contemplating the installation of automatic equipment is: "If we install an automatic unattended substation and if anything happens how will we know it and how long will it take to get out to the station and clear the trouble?"

That question is continually on the mind of the engineer and operating man. Conditions alter cases, but in general the above question is the limiting feature of the decision as to whether or not automatic equipment will be installed. Automatic equipment looks attractive because of the saving involved and better service rendered and if the chance is taken some form of supervisory indication is in demand.

AUTOMATIC RECLOSING SWITCH RECORD

_____ Station (or Territory) Month of _____ 19__

STATION	CIRCUIT	COUNTER READING This Month	COUNTER READING Last Month	Diff.	NO	EO	TESTS	LOCK OUTS	No. Oper. Since Overhaul	Date Last Overhaul

(Signed) _____
Station Chief

Fig. 1. Sample of operating record made up to tabulate data on automatic reclosing switches.

It is a question whether the cost of this supervisory indication is justified or not and it is believed that it is only a question of time until this indication will become an integral part of all automatic substation equipment.

Recommendations

From all indications the automatic substation, both in the railway and a.c. feeder types is just coming into its own and no doubt will become even more generally used as time goes on.

This committee was somewhat handicapped in getting reliable operating data. It appears that most companies have no systematic way of keeping operating records on their automatic substations. Thus the committee is reminded that just a few years ago the apparatus committee appreciated the real need for some systematic way of keeping oil circuit breaker records and as the result a definite form was recommended. Since that time very helpful data have been and are being collected.

Reliable information on automatic substations is equally important and therefore the committee wishes to recommend that all companies keep a systematic record of all operations. It is fully appreciated that at this time it would be impossible to set forth any outline that would meet all the member companies' requirements. However, if each company were to keep a complete record it would do a lot toward arriving at some definite form that possibly could be adopted later.

In Fig. 1 is shown a form used by the Southern California Edison Company for its automatic reclosing substations.

Automatic Equipment in A.C. Subtations*

THE advent of the automatic reclosing type of substation has started a wide-spread desire for automatic control of feeder circuits. The present dependable operation of automatic substation equipment and the excessive cost of labor, together with the feasibility of automatic control from remote points has made the demand insistent. The primary object in automatic feeder control is the restoring of interrupted service as quickly as possible, at the same time precluding the possibility of damage to apparatus.

Operating records show that 92 per cent of all kick-outs are caused by troubles that clear themselves and thus permit the breaker to stay in after the first, second or third reclosure. Therefore, any device that automatically will reclose the circuit breaker after it has been tripped out is a valuable piece of equipment.

The type of service to which automatic reclosing equipment is applicable is where substations are supplying power to, and located near manufacturing plants where an attendant would be available immediately in case of feeder lockout; or in suburban stations of a maximum of six or eight feeders where an interruption is understood by the consumers and they are willing to notify an attendant who lives near the substation and who would restore service as soon as possible.

In discussing automatic reclosing type of substations, the common thought is that they are only used on 2.2-kv. and 4-kv. feeders. As a matter of fact this is not true. Two companies use the reclosing features on their 11-kv. and 15-kv. outlying substations and another has one station where a 30-kv. switch is automatically reclosed.

There are several general methods used in accomplishing the automatic reclosure of oil circuit breakers. In all installations there is a definite time interval on one or all reclosures, necessitating some timing device. There are two different types of equipment where this timing is accomplished through the motor which furnishes the power for reclosing the breaker and another where a time relay is used.

The General Electric and Westinghouse Electric & Manufacturing Companies' type of reclosing equipment uses the timing relay. The gravity-type reclosing mechanism developed by the Southern California Edison Company and the gang-operated type of mechanism developed by the San Joaquin Light & Power Corporation and known as the S-2 type mechanism both use the operating motor for timing.

Details of the General Electric and Westinghouse automatic reclosing equipment are familiar to almost everyone and besides it is very well covered in the serial report of the N.E.L.A. electrical apparatus committee, 1927-28, and therefore needs no further discussion. However, since the gravity-type and the S-2 type of reclosure are new developments and have not been covered, some detail on this equipment may be of interest.

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* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

Gravity Reclosing Mechanism

The gravity type of reclosing mechanism was developed to meet a peculiar need of the Southern California Edison Company. The Edison company had a large number of outlying small capacity a.c. substations of the non-automatic type. There was an insistent demand for better service, but an operator at each station was not economically feasible and since the breakers were of various types of manufacture it was impossible to use standard equipment. As a result, the so-called gravity reclosing type of mechanism was designed and placed in operation. See Figs. 2, 3 and 4.

This mechanism consists of a motor and a series of gears, all of which are housed in a weather-proof box. The motor is a ¼-hp., single-phase machine, geared to revolve an arm at approximately one revolution per minute. The arm carries pins arranged to lift a weight lever through a certain distance and then drop it. These pins not only lift the weight which furnishes power for the closing of the breaker, but also serve as a timer. If two operations per minute are wanted, two pins are used and if only one is required, one pin is used.

A notching relay used for the purpose of determining the number of reclosures of the breaker consists of a cam arranged to be moved one step at a time by the operation of an actuating arm. This action is against a restoring spring so that the cam will be returned to the starting point when released. The cam is advanced one notch per reclosure and is held in position by a pall which is connected to a thermal arm. The cam permits the breaker to close three times against a fault and then lock out. On the third kick-out an alarm circuit is closed. If the breaker stays closed on the first or second reclosure for approximately ten seconds or more the thermal arm will reset the notching relay, again restoring all the equipment to a position where the three-reclosure cycle again is available for a subsequent fault.

This device does not permit all the variations that are possible in the equipments where timing relays are used, but it meets all the necessary service requirements of most small substations at a very much lower cost. The mechanism with a 20-lb. weight will operate the 400-amp., 4.5-kv. class of breakers, and with a 100-lb. weight will operate 400-amp., 30-kv. breakers, which are just within the average man's ability to operate by hand.

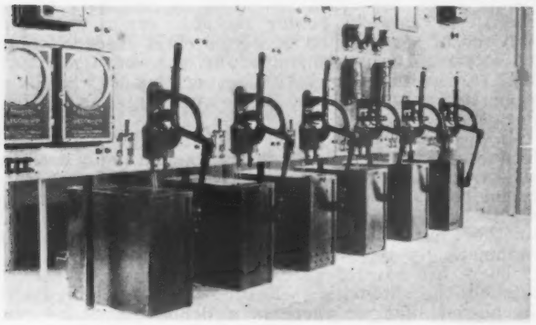

Fig. 2. Showing application of gravity reclosing mechanism to any small hand-operated breaker.

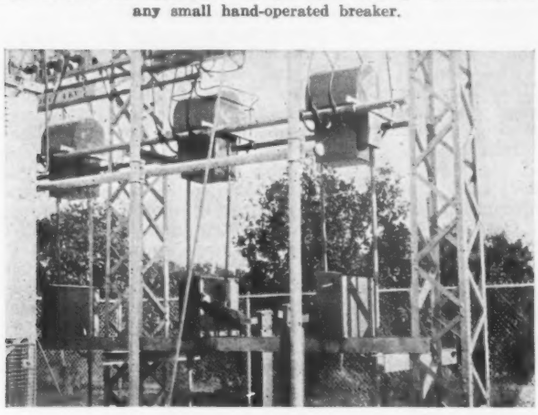

Fig. 3. Showing application of gravity reclosing mechanism to small outdoor 15-kv. breaker.

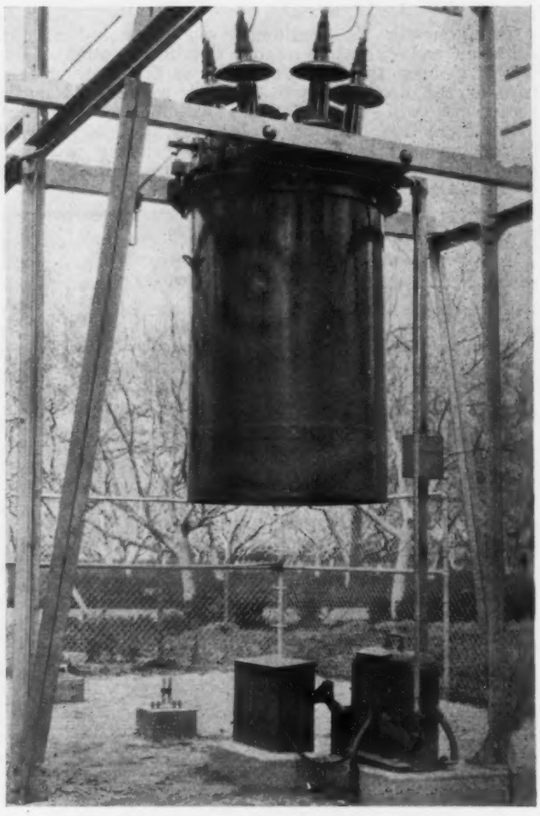

Fig. 4. Showing application of gravity reclosing mechanism to an outdoor breaker.

Application of Spring-Operated Breakers to Automatic Reclosing

In a recent design of a 60/15-kv. substation of the Southern Califronia Edison Company it was found desirable to provide automatic reclosing for 16-kv. breakers having motor-driven spring-operated mechanisms. The principal difference between the spring mechanism and the gravity mechanism previously described is that the motor compresses a spring instead of raising a weight. The motor and gears were selected so that about thirty seconds were required to compress the spring. A 32-volt d.c. motor was used. The same notching relay was used and serves the same purpose as on the gravity type of mechanism. The operation is as follows:

When the breaker is open by overload relays due to a fault on the line the notching relay starts the motor which compresses the spring. A pallet switch on the shaft closes as soon as the spring is compressed. This pallet switch closes the circuit through the closing solenoid which breaks a toggle and allows the spring to expand and close the breaker. If the breaker trips out the notching relay moves up one point and the closing operation is repeated. If after the third reclosure the breaker does not stay in, the notching relay prevents the motor from compressing

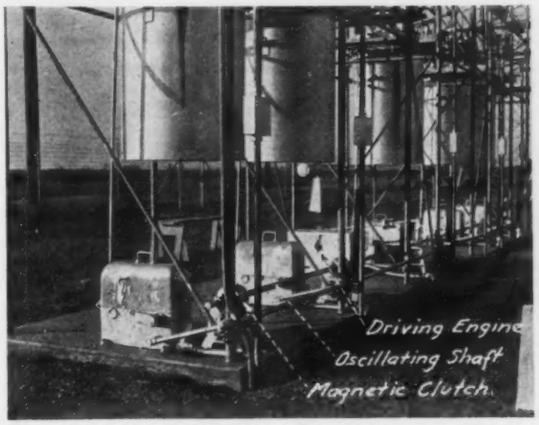

Fig. 5. Showing application of gang operating mechanism to outdoor breaker.

the spring and the breaker is "locked out." To reset the breaker to automatic operation the notching relay must be reset by hand at the mechanism. If, however, the breaker stays in on any of the reclosures the notching relay is reset by the thermal unlatching arm after about ten seconds. A tripping device also is provided at the mechanism.

This scheme seems to work out very well and it is expected that it will be the Southern California Edison Company's standard for this type of breaker.

Gang-Operated Reclosing Mechanism Type S-2

Automatic reclosing equipment developed and used by the San Joaquin Light & Power Corporation is a gang-operated reclosing mechanism known as the type S-2 (Fig. 5). It recloses successively any number of feeders up to six, only one switch closing at a time regardless of how many may have tripped out. Time intervals of reclosing may be varied from 30 seconds to six minutes and the number of reclosures from one to three. The mechanism is composed of a driving engine consisting of a motor, necessary reduction gears and timing contacts in a dust-proof housing, an oscillating arm, one magnetic clutch for each oil circuit breaker and a switchboard panel upon which are mounted a control relay for cutting the mechanism out of service, one lock-out relay for each oil switch, the motor control relay, and an operation recorder. Application of the automatic reclosing mechanism to the circuit breakers does not interfere with their being operated by hand.

The sequence of operation is as follows: When the circuit breaker trips out, one of its pallet switches closes, starting the driving-engine motor through the control relay and giving an alarm. The engine then locks the oscillating shaft on which the magnetic clutches are mounted and at the predetermined time interval the magnetic clutch is energized and its solenoids, by pulling up the plunger, lock the clutch lever to the shaft and close the oil circuit breaker once through the operating mechanism. Then the clutch releases. If the oil circuit breaker remains closed the reclosing mechanism operates idle for a short period and shuts down at the end of its cycle, the arm relay opening the alarm circuit. Should the trouble on the line persist and the oil circuit breaker again open, the mechanism continues to run and after the proper time interval the clutch is energized again and the circuit breaker closed a second time. This cycle is repeated until, after a predetermined number of times, the lock-out relay cuts the oil circut breaker out from automatic control and locks the alarm. This does not interfere with the successive automatic operation of the other oil circuit breakers.

When the alarm is answered, the lock-out relay is pushed half-way down which stops the alarm after the trouble on the line has been cleared; the oil circuit breaker is closed by hand, the lock-out relay pushed all the way down and then everything is ready to operate as before.

A Bristol six-pen recorder with seven-day chart is used to indicate the trip-outs. One pen is used for each oil circuit breaker and is operated by the closing of a pallet switch on the circuit breaker. When it is desired to inspect any oil circuit breaker the lock-out relay on that breaker is pulled half-way up, thus rendering the automatic equipment inoperative for that breaker only.

Automatic Reclosing Without Attendant

The Southern Sierras Power Company has four unattended substations ranging in capacity from 300 kva. to 750 kva. having 2.3-kv. or 4-kv. feeders protected by means of automatic reclosing oil circuit breakers. The breakers together with the control equipment are installed in individual outdoor all-metal houses. Protection is accomplished through the use of three induction overload relays per feeder.

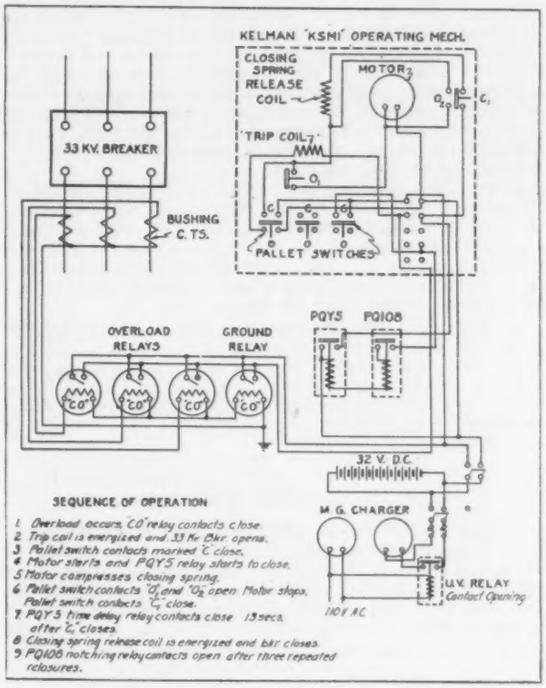
KELMAN "KSM" OPERATING MECH.
CLOSING SPRING RELEASE COIL
MOTOR
TRIP COIL
33 KV. BREAKER
BUSHING C.T.S.
PALLET SWITCHES
OVERLOAD RELAYS
GROUND RELAY
PQY5
PQ108
32 V. D.C.
M. G. CHARGER
110 V. A.C.
U.V. RELAY Contact Opening
SEQUENCE OF OPERATION
1. Overload occurs, CO relay contacts close.
2. Trip coil is energized and 33 Kv. Bkr. opens.
3. Pallet switch contacts marked C close.
4. Motor starts and PQY5 relay starts to close.
5. Motor compresses closing spring.
6. Pallet switch contacts O1 and O2 open. Motor stops. Pallet switch contacts C1 close.
7. PQY5 time delay relay contacts close 13 secs. after C1 closes.
8. Closing spring release coil is energized and bkr. closes.
9. PQ108 notching relay contacts open after three repeated reclosures.

Fig. 6. Control wiring diagram of 33-kv. reclosing oil circuit breaker operating equipment.

Two of the stations are equipped with induction-motor-driven timers to accomplish periodic reclosures on breakers. This timer is the MD-2 type and is set on 15, 30 and 75 seconds time delay between repeated reclosures. Each breaker is provided with two sets of current transformers, one set energizing relays and metering equipment and the other for tripping off the breaker by means of tripping reactors. Overload relays are set to operate on 200 per cent overload.

The other two stations depend upon a PQY-5 plunger-type time-delay relay used in conjunction with a PQ-108 notching relay for the reclosing feature. A four-second time delay between each repeated reclosure is obtained with this set-up. With this arrangement the longer time interval and possibility of varying the time between the first, second and third reclosures as is the case with the MD-2 timer is not possible. This is due to the fact that the PQY-5 time relay recloses the breaker under a given time setting which is the same for each reclosure until the PQ-108 notching relay trips open after three operations. No doubt there is some advantage in the practice of using a longer time delay than that obtainable with PQ plunger type of relay as the operating records show that interruptions are more numerous on the circuits equipped with PQ relays for reclosing than those equipped with MD-2 timers.

It is believed that there are further advantages obtained with the MD-2 timer than with the PQ relay, since the latter is dependent upon air bellows for time delay. The needle valve of the air bellows is subject to clogging from small dust particles which would at least vary the time setting and might cause the relay to be inoperative. Experience has shown that in exceedingly warm localities the temperature in an all-metal switch house rises to as high as 150 deg. F. which tends to dry out the leather of the air bellows and to cause marked difference in operating time.

In addition to the above type of station The Southern Sierras Power Company recently installed at its Corona substation a d.c. motor-and-spring operated reclosing mechanism on one of the 33-kv. oil circuit breakers. Closing of the breaker is accomplished by a 32-volt motor compressing a large coil spring which in turn is released by a d.c. tripping coil. When released, the stored energy of the compressed spring expends its energy against a series of levers which causes the breaker to close.

Power for operating the mechanism is supplied from 24 cells of Type A4 Edison storage battery which is charged by a motor-generator set at a trickle-charge rate. In case of a failure of the a.c. supply an undervoltage relay has been installed to open the generator circuit thus preventing discharge of the battery by "motoring" the generator.

A type PQY-5 time-delay relay and a PQ-108 notching relay were rewound for 32-volt service. These relays accomplish the periodic operation and the lock-out feature of the breaker mechanism. Fig. 6 shows a control-wiring diagram of the 33-kv. reclosing breaker and also includes a description of sequence of operation.

Automatic Reclosing With Attendant

The automatic reclosing type of station with attendance usually is the type used where the service is of a higher class than is possible through a straight automaitc reclosing without an attendant. Due to economies in labor that can be had without jeopardizing service this type of station is becoming quite popular. In most stations it is only necessary to have one man on duty a portion of the time and the remaining portion of the day within call distance.

Since it has been found in practice that a very high percentage of the circuits that trip out stay in after the first reclosure and since the alarm is sounded only after the circuit breaker locks out, the operator is very rarely disturbed during the night. Table I gives a list of the automatic reclosing substations on the Southern California Edison Company's system, together with the number of circuits at each station that are automatically reclosed. Locust, San Vicente and Huntington Park substations are attended stations and have automatic reclosing on the 4-kv. circuits. All the other stations listed are unattended and have automatic reclosing equipment.

TABLE I—Automatic Reclosing Substations—Southern California Edison Company.

Station	Circuits	Station	Circuits
G.E. Equipment 4 kv.			
Arro	4	Monrovia	6
Compton	4	Orange	4
Hawthorne	5	San Marino	5
Manhattan Beach	4*	Charnock	4
Madrid	5	Garfield	6
Ramona	4	Lomita	4
Bandini	5	Montecito	3*
Covina	4	Perry	2
Huntington Beach	5*	Summerland	3
*2.4 kv.			
Gravity Reclosing Mechanism on 4 kv.			
Allen	4	Lynwood	5
Baldwin Park	3	Monte Vista	3
Crafton	2	Packers	2
Flanco	3	Sierra Madre	2
Holden	3	Washington	4
La Verne	1	Artesia	2
Montebello	3	Bicknell	1
Pico	3	El Monte	4
Santa Paula	5	Goshen	6
Santa Susana	3	La Canada	3
Altadena	5	Maywood	5
Belvedere	1	Norco	3
Downey	2*	San Dimas	1*
Garvey	3	Sycamore	3
Hollydale	3	Westminster	2
*2.4 kv.			
Gravity Reclosing Mechanism on 11 kv.			
Highland	3	Orange	1
Malibu	4*	Little Rock	4
Lomita	1*	Santa Susana	3
*16 kv.			

Others

	Circuits		
Del Sur	4	11 kv.	Western Electric—Mechanical
Locust	12	4 kv.	Solenoid operated—W. E. Timers
San Vicenta	6	4 kv.	Solenoid operated—W. E. Timers
Huntington Park	7	4 kv.	Solenoid operated—G. E. Timers

The Southern Sierras Power Company has two attended stations of the automatic reclosing type. One station which is supplied by a 33/2.3-kv., 1,500-kva. transformer bank has a six-circuit truck type switchboard. The oil circuit breakers are the Type FKR-132, 400-amp., 15-kv. equipped with MK motor operated mechanism. Reclosing features are obtained by the use of the PQY-5 relay in conjunction with the PQ-108 notching relay. The other station has two 2.3-kv. feeders protected by automatic reclosing breakers. The reclosing is accomplished through the use of an induction-motor Type MD-2 timing relay.

Very satisfactory operating results have been experienced with both types of equipment.

Supervisory Control

Supervisory control is a system of control through which it is possible to complete a large number of operations over a small number of wires. Such a system is particularly applicable in fairly congested outlying districts where it is possible to place in the hands of one operator the control of several stations, any one of which would not be large enough to keep an operator busy. The economies thus attained justify the employment of a higher class of operator than is feasible in small attended stations.

The Los Angeles Bureau of Power and Light follows the practice in outlying districts of first installing stations of the automatic-reclosing type and later, as the load justifies the additional service, changing to supervisory control.

Automatic Reclosing With Supervisory Indication

This type of station, so far as this committee's investigation goes, does not exist. However, it seems that there are types of service where indication is highly desirable for the automatic-reclosing type of station. It would seem that this type of station should apply to all urban and metropolitan substations where continuity of service is of importance. In other words, if the service is of enough importance that an interruption of 15 minutes or more is not allowable, then supervision is necessary. The addition of supervisory indication must balance its installation cost against the good will of the consumer. The advantages of supervisory indication are as follows:

1. The supervisor would know which feeder was in trouble.

2. He would know whether the feeder circuit breaker tripped in the station or whether junction breakers or fuses had blown outside.

3. The time of interruption would be decreased.

4. He would know immediately when the station had returned to normal.

5. He would know when a feeder tripped and remained closed on the first or second reclosure. This is an advantage because it might be advisable to patrol the line to prevent subsequent outage.

6. In case of system disturbance he would know immediately the status of the substation, whether normal or otherwise.

Automatic Equipment in Railway Substations*

THE automatic substation now is generally accepted as standard equipment for power conversion in railway service. Economies and other advantages to be realized have been so widely demonstrated and so thoroughly proved that the automatic operation usually is to be pre-supposed in any consideration of new substation equipment. Of the new railway substations installed in recent years more than 80 per cent have been automatic and in addition, numerous manual stations have been changed over to automatic operation.

When a study of the application of automatic railway substation equipment is made it must be borne in mind constantly that the ultimate purpose is to convert alternating-current energy into transportation service which, in turn, must measure up to certain predetermined standards. Joint consideration of substations, transmission and distribution systems, motive power and traffic are essential to the proper analysis and economical solution. It is only by such a study of the entire system that the major component parts can correctly be co-ordinated and apportioned.

One of the largest installations ever undertaken is that of the Cincinnati Street Railway Company. The supervisory equipment is designed to permit either full-automatic operation or direct control by the load dispatcher. Units controlled are of 1,000 and 1,500-kw. capacity each. When completed this installation will represent one of the most extensive applications of automatic control in the world.

The Sacramento Northern Railroad (Calif.) already has completed the installation of nine out of ten automatic equipments for controlling existing induction motor-generator sets. This installation followed that of three automatic 300-kw. synchronous converter stations. The first converter station was made portable, and installed in a standard box car. This was put into operation in 1920 and was the first automatic station in that vicinity. This portable unit has been moved from station to station to handle the load during the installation of the ten automatic equipments and has made possible the removal of old substation equipment to new buildings, without interfering with the service. This company also will install during the spring of 1929 a 500-kw., 1,500-volt, completely automatic mercury-arc rectifier in a new railway substation a few miles south of Sacramento.

The Pacific Gas and Electric Company has installed in a new substation in San Francisco a double-unit automatic station involving two 1,500-kw., 600-volt synchronous converters.

The Northwestern Pacific Railroad Company, (Calif.) is installing one double-unit station consisting of two 1,000-kw. synchronous converters, one single-unit 1,500-kw. synchronous converter automatic substation and one equipment for an existing motor-generator set.

The Honolulu Rapid Transit Company is installing two new automatic substations involving 1,000-kw. synchronous converters. These two substations and also the Northwestern Pacific Railroad substation will be provided with remote control and indication.

The Pacific Electric Railway Company (Calif.) has a total number of 14 automatic substations with rotating machinery in operation, the first of which was installed in 1918. The number of stations and capacities now are as follows:

Stations	Capacity	Voltage	
1	1,000 kva.	600	
5	1,500 kva.	600	
1	750 kva.	600	
1	1,500 kva.	1,200	two 750-volt converters in series.

The Los Angeles Railway Corporation has in operation one 2,000-kva. and four 1,000-kva. automatic substations. The four 1,000-kva. stations consist of a single unit for each station while the one 2,000-kva. has two 1,000-kva. units.

Mercury-arc Rectifiers

While the motor-generator sets and the converters have been used in railway service for some time, the mercury-arc rectifier as applied to railway work is comparatively new. There is an installation of this type at Inglewood, Calif., owned by the Los Angeles Railway Corporation. This station consists of two 500-kw., 600-volt, mercury-arc power rectifiers as shown in Fig. 7. They are connected to operate in parallel, but only one unit is permitted to come on the line at the same time. Either rectifier can be set to take the lead, but if the first fails to come on the line the second will take its place after a definite predetermined time has elapsed.

Equipment includes:

Two 500-kw., 600-volt mercury-arc rectifiers.
Two 543-kva., 16,000/540/935Y-540/935Y three-phase oil-cooled transformers.
Two interphase transformers.
Two negative reactors.
Automatic switching equipment.

Each rectifier has six anodes through the cover and a cathode in the bottom consisting of a pool of mercury. The low-voltage connection of the transformers is equivalent to two "Y's" and the leads are brought out from the end of each Y to the rectifier. The interphase transformer is used to connect the neutrals of the Y connections of the low-voltage windings of the main transformer. The negative of the system taps to the middle of the interphase winding. The d.c. reactor is used in the negative side to "iron out" the pulsations and ripples.

* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

Automatic switching equipment will function according to the following scheme:

Upon load demand as indicated by low voltage on d.c. bus, providing the contacts of the time switch are not open, and when three-phase a.c. of proper voltage value is available, the automatic control equipment is allowed to function. When the temperature of the tank is within predetermined limits and when the pressure in the tank is sufficiently low, the master control contactor No. 4 closes, allowing the exciting motor-generator set to start. The exciting arc is established and maintained under light load only. The oil circuit breaker is closed applying voltage to the main anodes. The rectifier then is connected to the d.c. bus through the load-limiting resistors. These resistors then are successively short-circuited and the rectifier assumes the load.

The second rectifier in the two-unit stations is started when the load on the first unit increases to and remains at or above a predetermined value for a definite time. The sequence of operation for the second rectifier is the same as given for the first.

In case the first rectifier does not start within a certain time after the indication is given by the starting element, the second unit is started and is controlled by the master element of the normally leading unit. Either rectifier can be made leading by means of the manually operated change-over switch.

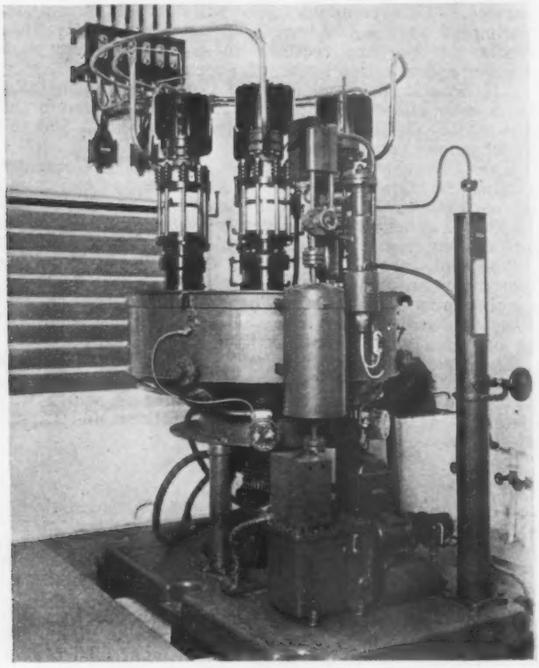

Fig. 7. Showing a modern mercury-arc rectifier.

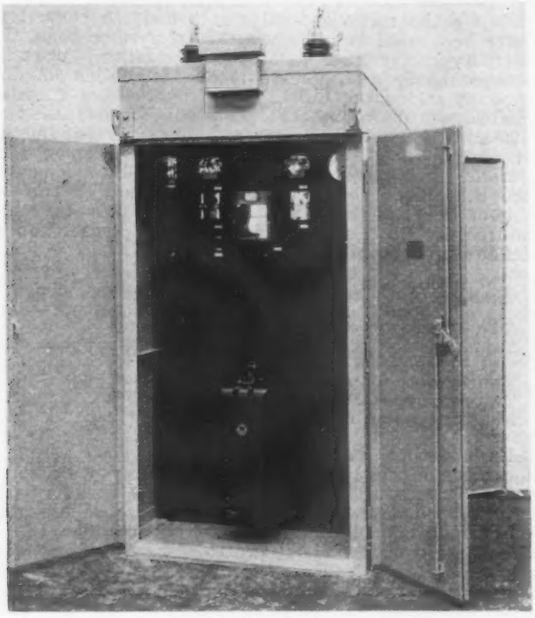

Fig. 8. One of the latest type of automatic reclosing circuit breakers in weather-proof housing.

The machine automatic equipment will:

1. Start the rectifier within a definite time after the bus voltage falls below a definite value. (This value is adjustable from 100 to 650 volts.)

1A. Start the rectifier immediately when the time switch gives the indication.

1B. Start the second rectifier within a definite time after the load on the first unit has increased to a definite value.

1C. Start the second rectifier within a definite time if the first unit fails to start after the indication is given.

2. Prevent starting the rectifier if:

(*a*) The a.c. line pressure is below a safe operating value.

(*b*) The a.c. power supply is single phase.

(*c*) The temperature of the tank is too high or too low.

(*d*) The pressure in the tank is not sufficiently low.

(*e*) The exciting arc fails to be established.

(*f*) The temperature of the main power transformer is too high.

(*g*) The load-limiting resistor temperature is excessive.

3. Connect the rectifier to the d.c. bus immediately after the oil circuit breaker is closed applying full a.c. voltage to the main anodes and establishing the main arc.

4. Shut down the rectifier within a definite time after the load on the rectifier has been reduced below 5 per cent (adjustable from 5 to 20 per cent) of machine rating and if bus voltage is normal.

4B. Shut down the second rectifier within a definite time after the total load on the station has been reduced below a definite value (depending upon the setting of the master current relay).

5. Shut down the rectifier temporarily if:

(*a*) The voltage of the a.c. power supply is too low for safe operation of the equipment.

(*b*) The rectifier is subjected to single-phase operation.

(*c*) The temperature of the tank becomes too high.

(*d*) The pressure in the tank becomes too high.

(*e*) The exciting arc should fail and not be re-established within a short time interval.

(*f*) The load-limiting resistors should tend to overheat.

5A. The rectifier will restart when the proper starting conditions are re-established.

6. Shut down and "lock-out" the rectifier if the equipment is subjected to harmful overload or short-circuit sufficient to require inspection, adjustment or repair before being placed in service again.

7. Shut down and "lock-out" the rectifier and its automatic control equipment in case of frequent arc-back or other trouble of a serious nature which might cause repeated opening and closing of the oil circuit breaker with short time intervals. After the oil circuit breaker is reclosed and tripped three consecutive times within a certain time limit the equipment is locked out.

8. Maintain the tank temperature at a suitable operating value.

9. Maintain the pressure in the tank below a certain maximum value.

10. Cut off the exciting arc when the load on the rectifier exceeds a certain value and re-establish the exciting arc when the load drops below this value.

The d.c. reclosing feeder equipment with high-speed circuit breaker will:

1. Allow current to be supplied for a maximum time to all useful loads.
2. Disconnect the feeder instantly from the source of power supply when load indicates that power is being dissipated in short-circuits.
3. Disconnect the feeder if the current is beyond a maximum steady value.
4. Discriminate between short-circuit and useful load when feeder is disconnected.
5. Reclose on stub or multiple feed from either side.
6. Disconnect the feeder in case of voltage failure.
7. Reclose the feeder within a minimum definite time after the feeder has been disconnected, provided the load is not excessive and voltage has been restored.

Semi-Automatic Substations With Attendant

This type of equipment applies very nicely to substations supplying communities where the service is of a miscellaneous nature. Economies in labor can be obtained without jeopardizing service if the rotating equipment is made semi-automatic and the feeders are automatic reclosing.

As an example, the Pacific Gas and Electric Company operates a substation containing:

9 rotating machines,
112 4-kv. distribution feeders,
10 street-light transformers, and
28 11-kv. power circuits.

The nine rotating machines were made fully automatic on the a.c. side and the 4-kv. feeders were equipped for automatic reclosing. As a result a saving was made in labor costs and a substantial decrease in the time of outages, which has materially improved the service.

Remote Metering

Remote metering always is welcome and probably justified in large systems where there are ten or more substations involved.

There are instances of course that require remote load indication. As an example, the Pacific Gas and Electric Company has a substation wherein the load characteristics are known and are the same for each day. The load demand is heavy and almost instantaneous. Therefore, it was concluded that it was best to start the two motor-generators by supervisory control in order to have them ready to take load and to make the other devices automatic in operation. When this was done it became apparent that the supervisor must know the load on the running machine to tell when to start the second and also to know when to shut down a machine when the load decreased.

New Developments in Automatic Substation Equipment

By P. B. GARRETT*

ASIDE from detail improvements and modifications the most prominent progress in the field of automatic periodic reclosing substation equipment has been in connection with the mounting and housing of such equipment. The practice of mounting such equipments in outdoor switch houses as illustrated in Figs. 8 and 9 is becoming more and more common.

A rather unique application of automatic reclosing equipment in an outdoor switch house is illustrated in Fig. 10. This show a special switch and mechanism house mounted on the frame work of the new type FO-24, 15-kv. oil circuit breaker. It may be noted that the panel supporting the relay equipment is hinged to facilitate inspection of the rear of the panel.

* Westinghouse statement incorporated as a part of the report of the automatic substation subcommittee of the electrical apparatus committee, Engineering Section.

Supervisory Control

The automatic equipment with its complete local electrical control and operation is suitable for the

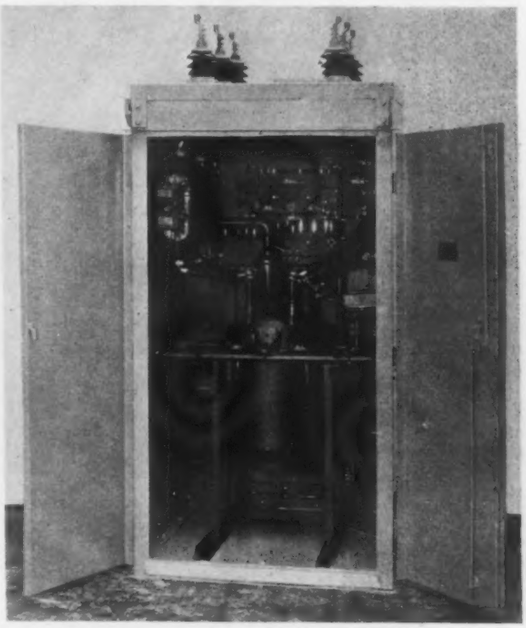

Fig. 9. Rear of panel. Fig. 8 shows front of panel.

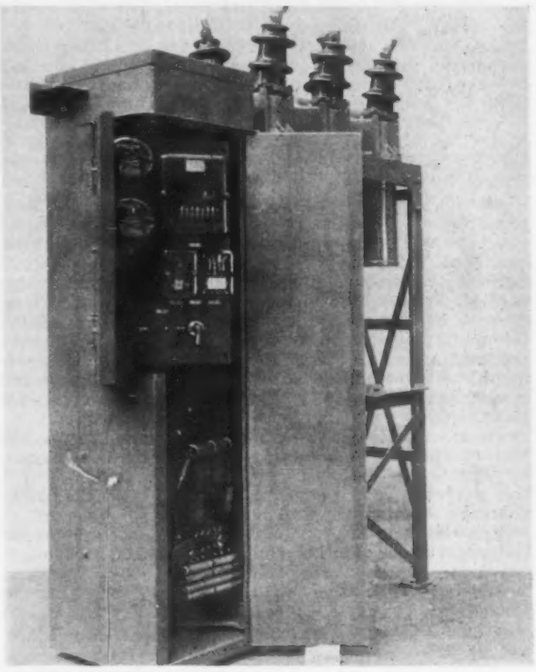

Fig. 10. Showing a special switch and mechanism housing.

application of the various systems of remote supervisory control. By this means the automatic operation can be supplemented by complete optional control of either system from a central point including complete visual information as to the status of all the units and major control devices.

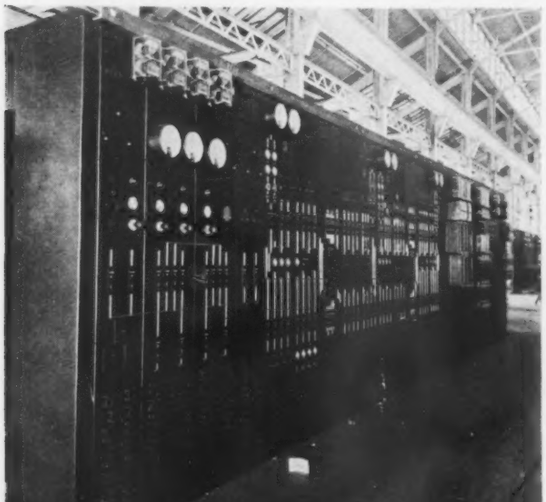

Fig. 11. A supervisory control board for the New York Edison Company controlling 130 circuit breakers.

It should be noted particularly that to supplement the automatic equipment in the substation with remote supervisory control does not imply any lack of confidence in the automatic equipment. Although the automatic substation equipment is entirely adequate to take care of all the normal and abnormal conditions for which it was designed, it often is desirable to provide optional control in the form of supervisory control to take care of unusual conditions which can be handled better in this way than to incorporate such control in the substation equipment itself.

Although there has been no change in the basic principles underlying the design of the Westinghouse supervisory control equipments, very material progress has been made in the simplification of the circuits. Such equipments are being more and more widely applied as indicated in Fig. 11 showing supervisory control equipment built for the New York Edison Company as set up for shop test. This equipment represents the largest single supervisory control equipment built to date. This equipment controls 130 circuit breakers and provides for 100 meter indications.

An example of the installation of supervisory control equipment in outdoor switch houses is covered by Fig. 12. The necessary batteries are placed in the steel box within the switch house and the trickle charging equipment is mounted on the sides of the switch house at the rear of the steel panel upon which the supervisory control equipment is mounted.

Remote Metering

A new system of remote metering has been developed which makes use of the same rectifying principle incorporated in the Rectox unit used for the trickle charging of radio "A" batteries. Rectification of the alternating current is obtained by means of prepared copper discs and the use of rectifying tubes thereby is eliminated. The new system is ideal where the metering of amperes (a.c.) is required. The D'Arsonval type of graphic meter may be utilized in the dispatcher's office, in which case the only moving element in the system is in the standard graphic meter at the receiving end and no auxiliary source of energy is required to operate the equipment. The accuracy is very high. The response of the meter is equal to that of the meter alone.

Alternating current for the potential and current instrument transformers is fed to the Rectox rectifier through a suitable transformer. For a given a.c. input to the Rectox from the instrument transformers there is a corresponding rectified direct current available at the d.c. terminals of the rectifier. The d.c. output of the rectifier is connected over the line wires to a d.c. milliammeter at the dispatcher's office. For a given a.c. input to the rectifier there is a proportional output of direct current. The meter at the dispatcher's office is calibrated to correspond with the input and output of the rectifier and therefore gives an indication of the current or voltage, as the case may be, which is fed into the rectifier from the instrument transformers.

It may be of interest to note the operating experience of the New York and Queens Electric Light &

Fig. 12. A supervisory control equipment mounted in weather-proof house.

Power Company with the supervisory control equipment installed on their system. The company keeps very accurate records of all operations. These records show that out of a total of 135,650 operations not one false operation or indication has occurred. Such experience establishes supervisory control equipment on a high plane of reliability.

Short-Circuit Discrimination

Short-circuit detector-type automatic reclosing d.c. feeder equipment has been developed which provides positive discrimination between short-circuits and legitimate loads. Short-circuit detection is accomplished in this type of equipment primarily through operation of the detector elements in response to two characteristics of a changing feeder current; first, the

average rate at which the feeder current builds up; and second, the length of time during which the current continues to rise. Except in special cases where it may be desirable to use it as a biasing or auxiliary effect the total value of feeder current has no place whatever in the tripping scheme. Operation on duration of current rise together with other special features makes possible an exceptionally wide range of selectivity between short-circuits and load swings.

This equipment is based upon the fundamental consideration that the most important function of d.c. feeder equipment in railway service is to isolate promptly all faults in the d.c. system and to maintain power supply on normal feeders at all times regardless of load conditions. On any d.c. railway feeder section it always is the most remote short-circuit that is most difficult to detect, other conditions being equal, as both the magnitude and rate of change of short-circuit current are least under this condition. At the same time the load swings most difficult to handle without circuit opening are those incident to the maximum concentration of the largest cars, trains or locomotives which might be in the immediate vicinity of the feeder equipment under consideration. The problem is, in general, to discriminate between these two conditions as experience has shown. If this is accomplished the equipment will discriminate between either combinations of short-circuits and load swings occurring on the same type of feeder circuit of equal or less length.

The performance of this feeder equipment was demonstrated during short-circuit and concentrated load tests conducted on the system of the Staten Island Rapid Transit Company. Since this is a third-rail system short-circuit detection is most difficult. For instance, in one section a sustained short-circuit amounted to less than 75 per cent of the probable legitimate demand on the feeder and the feeder inductance was so great that the current required approximately one and one-half seconds to build up to final value.

The wide range of detective ability of the equipment was shown by actual tests in which the same feeder equipment which held on to a load of 4,350 amp. with a single swing of 2,150 amp. repeatedly picked out and isolated short-circuits which amounted to only 1,950 amp. at the time the feeder breaker opened.

Circuit Interrupters for Railway Feeder Circuits

Because of the more exacting requirements and the higher standard of performance expected of devices

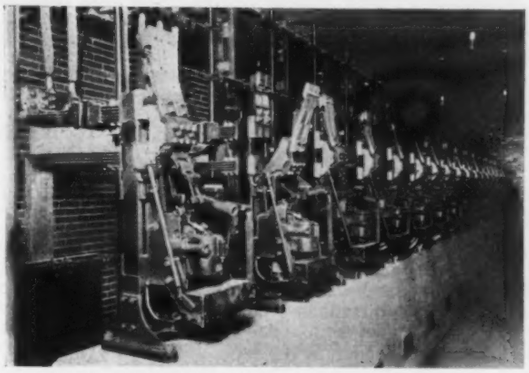

Fig. 13. A pedestal-mounted d.c. circuit breaker.

for use in unattended automatically controlled substations the carbon circuit-breaker arc has been very carefully reviewed in the development of a new breaker known as the Type CH circuit interrupter. The result is a device which retains the inherently good features of the older carbon breakers, but is more rugged and reliable and requires less attention and maintenance expenditure.

The CH interrupter is mechanically trip-free in all positions, a feature which insures performance on "OCO" cycle equivalent to that on the ordinary "CO" cycle. The breaker is exceptionally rugged mechanically. CH interrupters have completed 50,000 consecutive mechanical operations with very little wear, while electrically they have closed against and opened successfully 20,000 amp. at 600 volts at intervals of fifteen seconds, for one hour. Recently CH interrupters successfully opened 105,400 amp. at 600 volts without affecting their subsequent rated load operation.

A typical installation of pedestal-mounted Type CH circuit interrupters is shown in Fig. 13.

New developments have been made which increase the accuracy and reliability of the Westinghouse automatic d.c. reclosing equipment. The principle of operation is to measure the resistance of a de-energized feeder section and then to energize that section only if the resistance is sufficiently high to indicate that a short-circuit does not exist at any point in the section. An extremely sensitive relay has been developed for use as d.c. reclosing relay No. 182.

Flashover and Reverse Current Protection

In the past flashover protection has been provided in the form of a separate relay the coil of which was connected between the machine frame and ground. The contents of this relay in turn operated in the circuit of the lockout relay to lock the station out of service.

The flashover relay now has been replaced by a shunt trip coil on the d.c. emergency breaker No. 17. This trip coil is connected from the machine frame to the substation ground plate and will operate at any voltage greater than approximately 50 volts d.c. In case of flashover, any arc touching the frame will cause a current to flow through the shunt trip coil thus tripping the emergency breakers which have an auxiliary contact in series with the master relay coil and will cause the machine to be shut down. This also provides protection against grounds in the machine windings as only a very small current is required to operate the shunt trip coil. Such an operation constitutes a lockout, as the emergency breaker must be reset by hand.

Most positive operation on flashover is secured in this manner and fewer operations are required in locking out the machine.

Improvements have been made in the Type D d.c. reverse-current relay which prevents any reverse-current operation or "motoring" of the machine from the d.c. end. In addition to improvements in the moving elements of the relay, the case of the relay has been redesigned and a glass front has been provided to facilitate inspection without removal of the cover. Where it formerly was necessary to remove the entire case of the relay in order to make adjustments or repairs, it now is necessary only to remove a cover plate on the front of the relay case.

Motor-Generator Substations

There has been an interesting development in connection with the transition relay No. 19 which operates to change a machine from the starting to the running connections. A Rectox element now is utilized as a current valve in the circuit of relay No. 19 preventing that relay from operating in case the generator has built up with the wrong polarity. This eliminates the necessity of a polarity relay and also serves to simplify the automatic switching equipment.

New Developments in Automatic Substation Equipment

By W. C. STANLEY*

A new type of automatic supervisory equipment known as the synchronous selector type has been developed by the General Electric Company.

The principal device used in this system is the selector unit which consists of five rows or banks of 25 contacts each, making a total of 125 contacts arranged in a semi-circle. There are five "wipers" or moving blades on a common shaft actuated by a driving magnet. The five banks of contacts can be designated as the synchronizing, notching, control, indication and transfer banks corresponding to their functions. One of these selector units is mounted on the dispatcher's panel and one in the remote substation and only four wires are required for connection between the dispatcher's office and the substation.

Briefly, the functioning of the system, beginning at the dispatcher's office, is as follows:

Assume the system at rest. Before the dispatcher tries to perform any operation, he has to note that the white lamp associated with the start key is lighted indicating that the selectors in the dispatcher's office and the outlying station both are in the zero, or starting position. In case this white light is not burning, the dispatcher should synchronize the selectors in both stations by pushing the synchronizing key. It is not possible to operate the system if both of the selectors are not in the zero, or starting position.

Whenever the dispatcher desires to operate any oil circuit breaker or equivalent unit located in the outlying station he first pulls the selecting key associated with the unit he desires to operate. By pressing the start key the selectors at each station step in synchronism to the selected position and stop; the associated amber lamp lights indicating that the selectors have reached the desired position. A control and an indicating circuit for that unit thus are connected to the control and indicating wires and the dispatcher can perform the desired operation by turning the individual control key and pressing the master operating key. The changed position of the supervised unit will be indicated instantaneously by the red and green lamps. Upon completion of this operation he presses the selecting key which permits the selectors to return automatically to the zero position. The pilot-light key also should be depressed to extinguish the pilot lamp so that it will be ready for the next operation.

Upon reaching the zero position the alarm bell (either single-stroke or continuous ringing) rings and the white lamp is lighted indicating that the system is ready for a new operation. However, if he so desires, the dispatcher may select successively any number of positions during a single rotation, provided they are taken in sequence.

With the supervisory system at rest, assume an automatic operation of an outlying station breaker. The breaker auxiliary switch starts selectors which automatically check the position of all units supervised. During the operation an indication is sent over the indicating wire to light the correct indicating lamp in the dispatcher's office, and the alarm bell calls the dispatcher's attention to this. Also the individual white light for this unit is lighted so that the dispatcher can easily locate the unit which has operated. Similar operation takes place in case of simultaneous operation of more than one outlying station unit. The dispatcher can extinguish the white light and reset the trip-free device for the breaker by selecting the supervised breaker and turning the control key so as to correspond with the position of the breaker.

If for any reason, such as inductive interference, the dispatcher's office and the outlying station selectors are thrown one notch out of step, the selectors stop immediately and the dispatcher cannot perform any control operation. Thus no false operation can take place. The dispatcher has to push the synchronizing key, return the selectors to the zero position, and start the operation all over again.

The position of all units indicated may be checked at any time by pushing the starting key.

The trip-free feature is incorporated in the auxiliary equipment at the outlying station. A breaker when tripped open by a protective device, therefore, cannot reclose until this trip-free device has been reset (except in the case of automatic reclosing equipment). The dispatcher resets the trip-free device by performing the same operation as that for tripping the breaker.

* General Electric statement incorporated as a part of the report of the automatic substation subcommittee of the electrical apparatus committee, Engineering Section.

Automatic Substation Practice of the San Joaquin Light & Power Corporation

By E. W. OTTO*

FOR this report El Nido substation, 12 miles south of Merced (Calif.) has been chosen, as its features are perhaps typical of the present-day practices in automatic substation construction on the system of the San Joaquin Light and Power Corporation. It was built to serve a seasonal irrigation load and is shut down during the winter.

This is an outdoor type substation, has no rotating equipment and the feeder switches are automatic-reclosing without supervisory control or an attendant. Buses, disconnects and air switches in the 70-kv. yard are supported by standardized galvanized steel towers. All 11-kv. buses and equipment are supported by a pipe rack which is standard with this company. Two 70-kv. lines with non-automatic oil circuit breakers feed the main bus which in turn supplies, through an automatic switch equipped with a bypass, a 70/11-kv. transformer bank of 3,750-kva. capacity. The line switches are hand-operated and are installed only for sectionalizing purposes. A high-voltage transfer bus is provided to bypass the station or inspect the line switches.

The transformers feed the 11-kv. main bus through a master switch that is automatic, but not reclosing. The four 11-kv. feeders are all automatic-reclosing. Provision is made by means of a transfer bus for bypassing the master or feeder switches for inspection. An 18-ft. square plastered brick building with red brick roof houses the switchboard equipment and battery. The switch yard is surrounded by a six-foot fence.

Relays

No special relays or relay connections are used in stations of this type. Overload relays connected to bushing-type current transformers are used on the 11-kv. feeder and master switches. Current settings are such that the feeder switch always will trip out in case of line trouble, the master switch operating only for bus trouble or failure of a feeder switch. Overload relays also protect the transformer bank on the high-voltage side. Line switches are non-automatic at unattended stations, thus making the substation the equivalent of a tap. Where there is a part or full-time attendant, directional relays are used

* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

on the line switches. If the operator is only a part-time or "combination" man, relays on the line switches must be blocked by him when leaving the station.

A special automatic switch-reclosing relay developed by the company is in use at three of the earlier stations, but, while it has operated successfully, for economic reasons the S-2 reclosing mechanism has been used in all of the latter substations. This relay is described on page 117 of the 1925 P.C.E.A. Proceedings.

Operating Experience and Maintenance

In general the type S-2 gang reclosing mechanism has been satisfactory. There are very few cases where the mechanism has failed to operate correctly. Some minor mechanical and electrical troubles develop occasionally and the secret of keeping these down to a minimum is a very thorough monthly inspection, which is the practice of this company. Failure of the motor to close the switch properly, due to a short-circuit close to the station pulling down the voltage as the switch reclosed, occurred in one instance and interrupted the whole station. An auto-transformer now is used in the motor circuit to raise the voltage somewhat and guard against this happening again.

While in the past, three reclosures with short time intervals were made, the practice now is one reclosure with a 2½-min. interval. It is believed that if the switch will not stay in on the first reclosure, its chances of staying in on the second or third are remote. The longer time, while it tends to relieve the duty on the switch, is necessary where deep-well pumps are used, because the water running back into the well drives the motor in a reverse direction when the power goes off and should the power come on again before the motor comes to rest, it will twist off the shaft.

Full data are not available, but from 12 stations the following figures are compiled:

Year	Total Number Trip-outs	Number of Lock-outs	% Trip-outs Closed O.K.
1927	264	70	73.5
1928	229	54	76.5 up to Dec. 1

The number of trip-outs at different stations that stay in when reclosed varies from 54.5 to 93 per cent.

The avarage number of trip-outs per year per feeder switch is 4.5. When a switch locks out, the line is patrolled in an effort to locate the trouble and remedy it before attempting to restore service.

When the length of line is not too long, the alarm at unattended stations is run to the nearest district office. Where this is not done a customer must call in to notifiy the company that the power is off. Experiments now are being made on a simple carrier-current scheme for the alarm to be used on the phone lines. From all indications this will provide a cheap method of running the alarm any distance where a phone line is available, as it usually is.

Economics

There are several points to be brought out in a discussion of the economics of the substation with automatic reclosing feeders.

For example, a new rural territory is opening up and as it cannot be served by any of the existing facilities, it is desired to build a new substation to serve it. The present load probably does not warrant a large-capacity station and uncertainties as to the extent of the load development or its seasonal character make it desirable to keep the initial cost as low as possible and yet give good service. In this instance the non-attended station with automatic reclosing feeders has much to recommend it. The reclosing equipment can be applied to the feeders at considerably less than the cost of an operator's cottage and it has practically 100 per cent salvage value in case the substation is abandoned. Further it is a capital charge that can be earned upon. The elimination of the operator and his salary represents a considerable saving in operating expenses, but against this there is extra auto mileage to be charged and slightly additional inspection cost.

The service rendered is as good if not better than if there were a 24-hr. operator, as the reclosing equipment will restore service. Should the trouble on the line be of such nature that the switch will not stay closed, it is necessary to patrol the line in any case. If the station grows in load and importance, a house can be built when needed for the use of a "combination" man.

A combination man is a substation operator who has other duties to perform besides attending the station and such an operator is used only at automatic-reclosing stations. His duties aside from operating consist of acting as a service man for the territory around the substation, replacing and removing fuses, sealing and unsealing meters and doing minor trouble-shooting jobs. This saves sending out a man from the district office and with an average of 50 calls a month per man and the distance in auto-mileage conservatively estimated at 20 miles each trip the reduction in auto-expense may be appreciated.

Installing automatic reclosing equipment on the feeder switches of previously attended stations and making the operator a combination man has been done satisfactorily in several cases. In concluding, it is company belief that the automatic substation as applied by this company is of real value in certain fields both from the standpoint of economy and of giving service.

Automatic Transfer Switching Equipment of the Los Angeles Bureau of Power and Light

By OSCAR WINGARD*

UNINTERRUPTED electric service as required by state and local ordinances to theaters, large buildings and similar public gathering places has, in the last few years, become of great importance. Especially so with respect to the numerous moving-picture theaters of large capacity.

This type of consumer was a few years ago confronted with the problem (forced upon him partly by local ordinances and partly by necessity of securing dual reliable sources of energy commensurate with the commercial importance of the enterprise) of choosing between the purchase of relatively high-capacity storage-battery equipment, or the purchase of duplicate standby electric service with a consequent increase in the monthly operating expense.

In 1925 the problem was solved by the Los Angeles Bureau of Power and Light which at that time initiated the practice of serving this class of business with two 4.6-kv. primary feeders, each from a separate major station and carried directly into a transformer room within the building in question.

When double feeder service was decided upon for these consumers, it was realized that manual transfer from one feeder to the other in case of interruption on either feeder was not satisfactory, as the time of restoring peace was very important. To take care of this delay an automatic transfer system was developed for installation on the primary side of the transformers.

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* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

Arrangement of the automatic transfer equipment was especially developed for operation entirely from the primary source of energy, so that the consumer and the serving company both were relieved of the purchase of any d. c. apparatus; the continuity of service demanded by the larger theaters and by ordinance was assured; and the consumer was enabled to purchase all of the electric energy required at the lowest rate applicable to the total consumption of the building. A brief description of the equipment and its operation is covered in the following paragraphs.

Equipment and Operation

The change-over equipment consists of two standard single-throw, three-pole oil switches and can be operated either by a low-voltage d.c. solenoid, an a.c. or d. c. motor-driven operating mechanism, or a motor-wound spring operating mechanism. Besides the oil switches with several extra pallet switches, the other equipment consists of two small control transformers of sufficient capacity to operate the a. c. motors directly when such are used, or two small potential transformers to operate an interposing relay when a low-voltage d. c. operating mechanism is used as, for example, 24-volt d. c. supplied from two standard 12-volt automobile storage batteries.

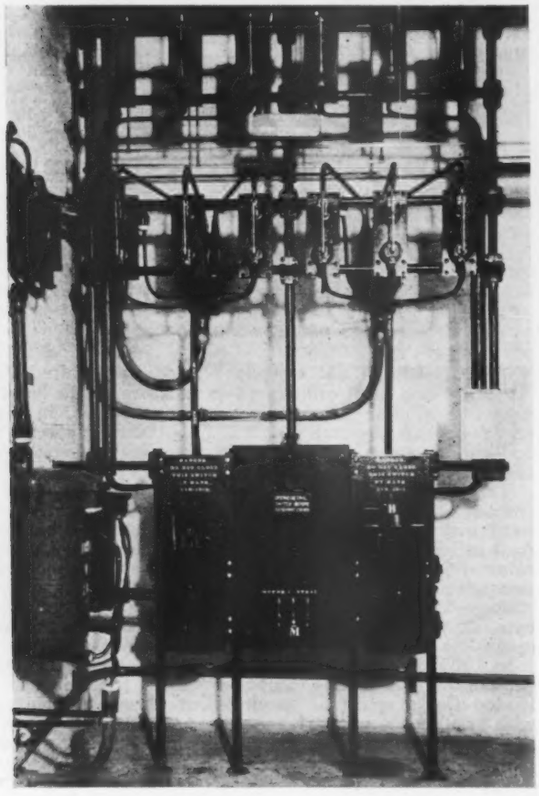

Fig. 14. Shows Installation of a.c. motor-operated transfer switch with its relays at center of panels.

A standard make of relay with a few minor alterations is used to energize the proper control circuits. The two control transformers are connected, one to each incoming feeder on the line-side of the oil switches.

Performance of the equipment is as follows:

One of the incoming feeders is selected as the preferred circuit, which for the purpose of this example is called feeder No. 1, and the other as the stand-by or emergency circuit, or feeder No. 2. In case feeder No. 1 fails or its voltage drops below a

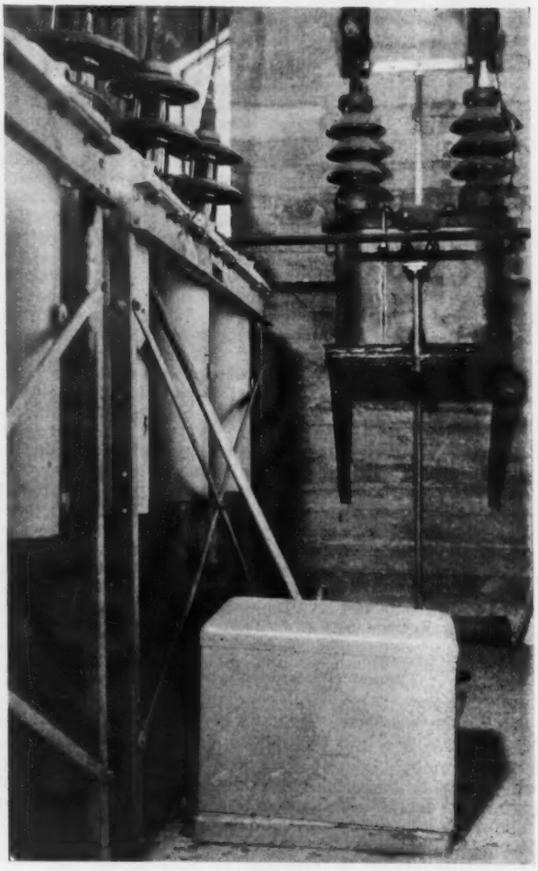

Fig. 15. A 33-kv. transfer switch at the University of California at Los Angeles.

predetermined value the relay which is constantly energized from No. 1 control transformer is de-energized and contacts under spring tension are closed. This energizes the trip circuit of No. 1 oil switch from the control transformer connected to No. 2 feeder. As No. 1 breaker opens, it closes a pallet switch which energizes the closing operating mechanism of breaker No. 2 from No. 2 control transformer, closing No. 2 breaker. This operation is instantaneous. When service is restored again on feeder No. 1 and its voltage is stabilized above its before-mentioned predetermined low-voltage value, the relay again is energized from control transformer No. 1. After a predetermined time setting of the relay, usually from 15 to 20 seconds, the relay again closes the first set of contacts which energizes the trip coil of No. 2 breaker from No.1 control transformer. When No. 2 breaker opens, a pallet switch on it operates to energize the closing operating mechanism of No. 1 breaker from No. 1 control transformer, thereby restoring the service on the preferred or No. 1 feeder. Either operation, from feeder No. 1 to No. 2 or back to No. 1 again is so fast that the flicker of the lights can hardly be seen.

Figure 14 shows an installation of a. c. motor-

operated transfer switches with its relay on the panel in the center. To the left may be seen the two pilot transformers. In this installation one of these transformers is larger than the other as it was used for some additional load.

Figure 15 shows half of a 33-kv. installation at the new branch of the University of California at Los Angeles. On the floor is shown a d. c., 24-volt spring-operated mechanism connected to one of the 33-kv. breakers. On the wall is shown a 200-watt potential transformer used as a control transformer to operate an interposing relay between the 24-volt battery and the spring operating mechanism. The only reason for using a 24-volt mechanism in place of 110- or 220-volt a.c. motors is the objectionable cost of larger than 200-watt, 33-kv. transformers for operating the equipment.

Automatic Substation Practice of the Pacific Gas and Electric Company

By R. B. KELLOGG*

AS AN example of a typical fully automatic non-attended substation of modern design, this company offers station "N", San Francisco.

This station was placed in service in September, 1928, and supplies power at 600 volts d. c. for part of the Municipal Street Railway system. It contains two 1,500-kw., 600-volt synchronous converters, one of which at present constitutes a reserve unit. The three-phase transformers for the converters are self-cooled and installed outside of the building.

High-voltage connections to the transformers are made without exposed wiring through oil-filled potheads provided in an inverted position in the cover. The high-voltage cables are wiped directly to these potheads and the connections to the coils are under oil inside the transformer. A pressure tank with the necessary piping and manifold interconnects these potheads to maintain a constant volume of oil in each terminal.

Reduced voltage for starting is obtained by Y-connecting the high-voltage windings of the transformer. Normal running voltage is obtained by connecting them in delta. Power is supplied for the station through two 11-kv., 3-conductor cables from station "E". The 11-kv. equipment consists of a single bus and "roll out" type oil circuit breakers. All 11-kv. equipment is enclosed in steel cells and the bus and oil circuit breakers are installed in a separate room.

The main switchboard as shown in Figs. 17 and 18 consists of the necessary panels for the two converters, four 2,000-amp., 600-volt automatic reclosing d. c. feeders, and two 11-kv. incoming lines. All heavy copper and disconnecting devices are installed on an auxiliary switchboard behind the main board. This feature clears the back of the main switchboard and makes accessible the small wiring and relay and instrument resistors for maintenance work. The negative bus is located in the pits under the converters and these pits serve also as air ducts for ventilation.

High-speed breakers and associated resistors are placed on a framework over the two machines. This feature constitutes a saving in heavy cable runs and facilitates maintenance and inspection. The load limiting resistors are installed on a balcony above the switchboard with the necessary shunting contactors directly underneath. This provides accessibility and good ventilation as the air rises from underneath up through the resistors.

* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

There are three sources of control, 230-volt a. c., 125-volt d. c., and 600-volt d. c. All wires for the three sources are kept separately and run in separate conduits and junction boxes. The 230-volt a. c. control system feeds from a power transformer protected

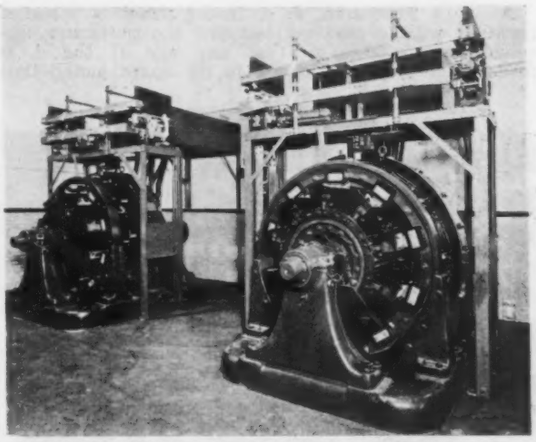

Fig. 16. Station N, San Francisco, Pacific Gas and Electric Company. Two 1,500-kw., 600-volt rotary converters showing framework over machines mounting high-speed circuit breakers and machine resistors.

by tetrachloride fuses. As a reserve, the 250-volt a. c. control system can be fed from the station house bank or from the a. c. street mains.

Ventilation is accomplished by means of an exhauster on the building roof controlled by a thermal relay. The exhauster pulls the air into the station

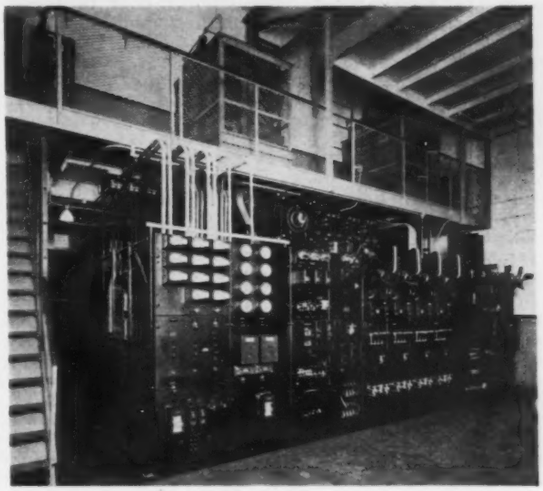

Fig. 17. Station N, San Francisco. Front view of main switchboard showing automatic equipment. Load-limiting resistors mounted on balcony above.

through a static air filter, thence under the two converters and up into the station, and thence through an air duct on the roof to the outside. A method of cooling the resistors by forced air is provided if this is found necessary.

The battery for 125-volt d. c. control is of the heavy-duty sealed-in type, and is located on a rack in the cable subway. No cabinet is necessary. The battery is of 200-amp.-hr. capacity and is trickle-charged by two bulb rectifiers, one of which is a spare which automatically cuts in in place of the first unit in case the first tube fails.

A spare 2,000-amp. d. c. feeder panel is installed together with a transfer bus and the necessary disconnecting switches so that any one of the d. c. feeder cables can be cut on to the spare panel, thus

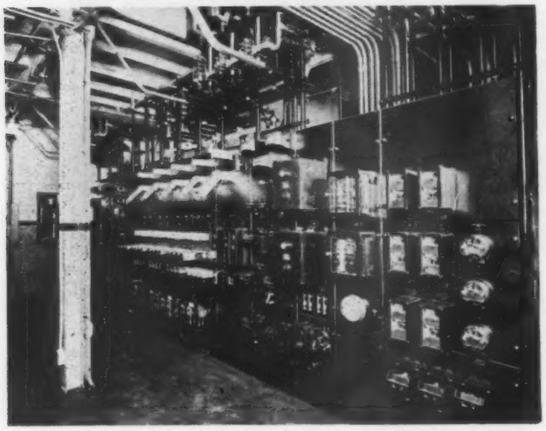

Fig. 18. Station N, San Francisco. Showing auxiliary switchboard located in rear of main switchboard.

clearing the main circuit panel for inspection or repair without de-energizing the feeder cable.

Power is metered by a watthour meter installed on each d. c. feeder panel. The kilowatt-hour consumption is totalized on one recording and totalizing meter. Emergency lighting is supplied from the battery in case of loss of all a. c. supply. Ordinarily, in case of loss of the station house bank, the service automatically is thrown over to the street supply. The building is of concrete, one story, approximately 43 x 32 ft. x 25 ft. high. The outside is finished in buff plaster and the inside is sound-proofed by means of a one-inch air space followed by Celotex and plaster finish. False doors are provided for further sound-proofing. The usual protective relays are installed which are more or less standard for automatic operation of synchronous converters.

Ordinary operation is as follows:

The station is placed in operation by low trolley voltage continuing for a definite time. Either of the two converters can be made the leading machine. The leading machine will start and take load. As the load reaches a value greater than machine rating, the second machine will start after a definite length of time. Likewise, the second machine will shut down as the load demand decreases. The first machine will shut down when the load reaches a low value for a definite length of time. In case the first machine does not start, the second machine will come on and take load.

High-speed circuit breakers are installed in the negative lead of each machine to prevent flashing on short-circuit or overload and to relieve the duty on the circuit interrupters installed on each d. c. feeder.

The d. c. feeders are automatic-reclosing. They open upon short-circuit and remain out until the short-circuit has been cleared. When the line is clear they reclose automatically. Their characteristic is such that the breaker will not trip on heavy overloads of short duration, such as an accelerating load caused by several cars bunched together, but they will open upon short-circuit located remote from the station which may draw the same current inrush as the accelerating load above mentioned. They will, however, open upon very heavy overload, such as would cut in the load limiting resistors and in consequence lower the bus voltage which would interrupt the service of the entire station.

An inexpensive signaling system is installed which notifies the operator at station "E", two miles distant, in case either machine is in trouble and has locked out. Briefly, this is accomplished by means of a current balanced relay located at station "E" and operating from current transformers in each of the two 11-kv., three-phase power cables supplying station "N". In case either converter locks out, one of the 11-kv. power cables is tripped. The unbalance thus established operates the balance relay at station "E" and a signal is given the operator. This signal is composed of a horn and signal light.

The station is designed for a third converter and is planned also to deliver 4-kv., three-phase a. c. distribution when the demand occurs.

Supervisory Control Practice of the Los Angeles Bureau of Power and Light

By OSCAR WINGARD*

IN THE San Fernando Valley section of the City of Los Angeles the electric load density is relatively light. However, there are a few centers where the load is sufficiently concentrated to warrant small distribution stations. These centers are separated by distances varying from five to eleven miles and it is planned to serve these stations from a ring transmission system and have all the equipment in the stations supervisory controlled from one point.

At present there are four of this group of stations built. One is a dispatching station from which a second station is controlled by a supervisory system. The other two have automatic-reclosing feeders at present, but soon are to have supervisory equipment installed. The ultimate scheme as now planned will have five stations controlled from the dispatching station.

The controlled stations in this group all have the same electrical and structural layout. Each station will be served by two 33-kv. lines from the ring system, will have two transformer banks and will have a capacity of five 4.6-kv., 1,200-kva. regulated feeders.

At each station there will be four 33-kv. switches and seven 4.6-kv. switches controlled and supervised, and eighteen meter readings will be supervised.

When the stations are first put into operation and until the load becomes sufficient to warrant the installation of supervisory control equipment, the feeders are equipped with automatic-reclosing mechanisms. These mechanisms are set for three reclosures and then lock out. This system proves very satisfactory and economical. During a period of approximately three years' service on four feeders, there have been six automatic operations of which two were lockouts.

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* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

In the station now under supervisory control, there are four switches controlled and supervised. This station has been in operation for approximately three years and during the last 22 months there have been approximately 35,000 operations of the supervisory system which includes half-hourly automatic checking. During this period there have been 35 cases of trouble on the supervisory system. In only two cases was the desired switch operation not obtained. Thirty-two of these cases were indicated by the automatic check, and in one case the system repeated on a switch closing operation. Of the 35 cases of trouble, 23 were in the supervisory equipment, one was battery trouble, seven were line trouble and four were fuse trouble.

Maintenance men make a weekly inspection of all supervisory and automatic equipment and periodically clean and adjust the equipment. Also there is an operator standing one shift a week in each automatic or supervised station. His duty while on shift is to clean up the station and take meter readings and

TABLE II—Details pertaining to 35 cases of trouble experienced by the Los Angeles Bureau of Power & Light in supervisory control circuits.

No.	Date 1927	Time	Description
1	Feb. 11	9:35 a.m.	Repeat on dummy test.
2	Feb. 14	2:00 p.m.	Repeat on closing operation.
3	Mar. 15	10:00 a.m.	Dummy test could not get through.
4	Apr. 23	10:00 p.m.	Fuse blown.
5	Apr. 27	7:45 a.m.	Kept buzzing after operation.
6	May 5	10:25 a.m.	Out of order.
7	May 7	11:30 a.m.	Failed to get code through on dummy.
8	May 11	10:30 a.m.	Failed to get code through on dummy.
9	Jul. 12	11:00 a.m.	Dummy test failed. Wires down.
10	Oct. 14	3:39 p.m.	S. C. failed to open. No. 3 O. S. D. S. No. 35. Found false indication.
11	Oct. 14	6:00 p.m.	Dummy check repeat.
12	Oct. 17	8:15 a.m.	Not checking properly.
13	Oct. 19	2:00 p.m.	Repeat on dummy test.
14	Oct. 27	9:45 a.m.	Super. line crossed with phone line.
15	Oct. 28	3:00 a.m.	Dummy test failed.
16	Nov. 1	1:00 a.m.	Repeated on dummy operation and rang alarm.
17	Nov. 1	5:00 a.m.	Repeated on dummy operation and rang alarm.
18	Nov. 3	6:00 a.m.	Alarm bell rang on dummy operation.
19	Nov. 4	3:30 a.m.	Alarm bell rang on dummy operation.
20	Nov. 9	2:30 p.m.	Alarm bell rang on dummy operation.
21	Nov. 25	9:55 a.m.	Failed to get check through
22	Nov. 26	7:40 a.m.	Out of order. Pulled fuse. Put fuse back. Checked O.K.
23	Nov. 26	9:00 p.m.	Out of order. Pulled fuse. Put fuse back. Checked O.K.
24	Nov. 26	10:00 p.m.	Out of order.
25	Nov. 27	1:00 a.m.	Open in line at bad joint.
26	Nov. 29	4:03 a.m.	Alarm bell rang on dummy test.
27	Dec. 10	9:10 a.m.	Battery trouble.
28	Dec. 28	1:00 p.m.	Alarm rang on dummy operation.
29	Dec. 29	8:32 a.m.	Line found grounded on guy wire.
	1928		
1	Jan. 26	7:52 a.m.	False indication on S. C. panel at DS No. 21.
2	Apr. 5	5:55 p.m.	Line open in a cable under pavement.
3	Sep. 5	1:30 p.m.	Control wires found reversed.
4	Oct. 10	4:00 p.m.	Failed to operate No. 4 O. S. at DS No. 35.
5	Oct. 13	3:30 p.m.	Fuse blown in Super. Con. at DS No. 35.
6	Oct. 26	10:30 a.m.	Line shorted. Pulling wires over lines.

temperatures. This operator is always on call and is the first person notified in case of trouble on the supervisory system. In case he is on duty in some other station, he locks that one up and drives to the station in trouble. With this system, four men can take care of six stations and eliminate fourteen operators.

The maintenance men inspect three or four stations in a day and as there has been but little trouble with this type of equipment, maintenance and inspection costs have been very small.

Details of the 35 cases of trouble are as shown in Table II.

Supervisory Control Practice of the Southern California Edison Company

By E. V. BOEKENOOGEN*

THE Southern California Edison Company recently completed its first supervisory controlled substation, a new consumers' substation built to take care of the increased capacity of the Columbia Steel Company plant at Torrance and located on their property. This plant formerly was supplied over 16-kv. lines, but with the increased capacity it was necessary to feed it from the 66-kv. system, which was done by looping a 66-kv. line which ran from Torrance substation to Watson substation.

Electrical layout of the substation consists of the two 66-kv. lines, a single bus and four 3,000-kva., O. I. N. C. O., 66/2.4-kv. transformers. The consumer is supplied at 2.4-kv. and from the 2.4-kv. bus, nine lead-covered three-conductor cables go to the load centers around the plant.

The supervisory control used is the General Electric selector type, the dispatcher's station being at Torrance substation, a distance of approximately 1.6 miles from the steel plant. The present layout provides for the opening and closing of three oil circuit breakers and indication by red and green lamps of the open and closed position of these breakers, also temperature alarm and indication on the bank, and lockout alarm and indication on the Columbia Steel Company feeder breakers. The Columbia Steel Company equipped its feeder breakers with lockout relays so that in case of severe shorts on these feeders, the breaker on the feeder in trouble will not trip out, but will throw the duty on the Edison Company's high-side transformer breaker, tripping it in on overload. These lockout relays were required because the feeder did not have sufficient interrupting capacity. When these relays function, an indication and alarm is sent over the supervisory system to the dispatcher's station. After the Columbia Steel Company operator has opened the breaker on the feeder in trouble, he resets the lockout relay which reverses the indication at Torrance and the operator there knows everything is clear and closes in the high-side transformer breaker.

Connections between the Columbia Steel Company substation and Torrance substation, for the supervisory system, were made with a two-pair No. 14, lead-covered, 600-volt, rubber-insulated cable. This cable leaves the substations at each end underground to the first pole and is carried suspended on a messenger cable fastened to the existing telephone cross-arms on the poles. This pole line has 66-kv. and 16-kv. circuits on it. In using lead-covered cables no arresters were required, the only protection being the grounding of the messenger cable at numerous poles. Although only three line wires are required for the operation of the supervisory system, the fourth wire was added so that another further substation in that district could be controlled. Although the system has been in service only a short time, there have been a number of operations which it has handled successfully.

* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

Supervisory Control and Remote Metering Practice of the Los Angeles Gas and Electric Corporation

By L. A. BUESE*

THE purpose of supervisory control as used by this corporation is to reduce operating costs of substations in districts where the load is insufficient to keep an operator fully occupied. The substations are classified in three groups—heavy, medium and light—according to the load density of the districts they serve. Substations in heavy-load districts have operators on duty 24 hours a day, in eight-hour shifts. Substations in medium-load districts have operators on duty in the station from 8:00 a. m. to 10:00 p. m. From then on to 8:00 a. m. the following day the station is in charge of the operator who lives in a house on the substation property. He is not required to remain in the substation, except in case of trouble, but he must remain on the substation property and be ready for call. Substations in light-load districts are operated by supervisory control from a medium load substation. In this manner it is possible to give 24-hour service on all substations without prohibitive expense.

A typical substation under supervisory control has three 16.5-kv. highlines, one 3,000-kva. and one 5,000-kva. transformer bank 16.5 kv. delta to 4 kv. star, and six 4-kv. distribution feeders designed to carry 1,000 kva. each. Each highline has one oil circuit breaker connected to two 16.5-kv. buses through a double set of disconnects. Each transformer primary has one oil circuit breaker feeding from the two16.5-kv. buses by means of a double set of disconnects. The transformer secondaries have two oil circuit breakers feeding two 4-kv. buses. The distribution feeders have one oil circuit breaker from each bus, one feeding through the regulator and the other feeding directly to the feeder. In some cases the feeders are equipped with 300-amp. 5 per cent reactors.

All oil filled apparatus is enclosed in concrete cells having Transite doors. These cells are equipped with automatic sprinkler heads, which in case of fire, release carbon tetrachloride from two 50-gal. tanks at 100-lb. pressure.

The main switchboard is typical of any electrically operated substation and the station can be controlled from this board the same as any other station. A recording kva. meter is connected to each transformer bank secondary. One recording kva. meter, three recording ammeters and three recording voltmeters are mounted on the board and transfer jacks are provided at each distribution feeder panel, so that any one of these meters may be connected to any distribution feeder. The station battery is kept charged with two bulb-type trickle chargers.

The supervisory control will operate any oil circuit breaker in the station and will operate a solenoid for opening the rear door of the substation. It will give an indication as to the position of any oil circuit breaker whether it be opened or closed and will give a signal alarm to the control station if any breaker changes position, if any outside door in the substation is opened or closed, if the 4-kv. bus loses its potential, if the d. c. bus feeding the overload relays loses its potential, if the pressure drops on the fire extinguisher tanks and if any induction regulator goes to maximum buck or boost position. In addition to the signal alarm, the control station will receive a definite indication as to which piece of apparatus has caused the alarm. The operator at the control station can read the load on each transformer bank secondary and the voltage on each 4-kv. bus. The regulated voltage of each distribution feeder can be read by clearing the auxiliary 4-kv. bus from the transformer secondaries and closing one distribution feeder at a time to the auxiliary bus and reading that bus voltage.

The supervisory control equipment at the substation under control consists of four 16 x 90-in. pressed steel panels. On two of these panels are mounted the relay cases containing the telephone type supervisory control relays. On the third panel are mounted the interposing relays which receive the control impulses from the supervisory control relays and close their own contacts to supply the heavier current for completing a closing or opening operation of a circuit breaker. The fourth panel contains one transmitting ammeter and one transmitting voltmeter and the auxiliary relays for connecting only one voltage or one current at a time to the transmitting meters. These transmitting meters operate on the Kelvin balance principle and transmit d.c. milliamperes in proportion to the a.c. voltage or amperes connected to them. At the receiving end this current is passed through d.c. milliammeters having scales printed in calibrated proportion to the a. c. voltage or current to be read. In this way resistance of the circuit between stations does not affect the meter reading.

Control wires for operating an oil circuit breaker by supervisory control are connected from the interposing relay panel to the main switchboard where they are multiplied with the regular control wires at the various circuit breaker panels. The supervisory wires for showing the position of oil circuit breakers or other apparatus are connected from the supervisory relay panel directly to the pallet switch on the apparatus.

The supervisory control apparatus at the control station consists of five 20 x 90-in. pressed steel panels for each substation under control. On three of these panels are mounted small copper buses arranged as a single-line diagram of the controlled station. Each circuit breaker is represented in its correct electrical position by a bakelite plate on which is mounted a control key for operating that breaker and a red and a green lamp showing the closed or open position of the breaker. For apparatus under supervision only such as the fire extinguisher tanks, regulators and buses, there are suitably marked bakelite plates having a red and a green lamp, indicating whether or not the apparatus is functioning properly.

An ammeter is provided for reading the load on the transformer banks and a voltmeter for reading the voltage on the 4-kv. buses. There are bakelite plates having small switches on them which will cause the meter to be connected to the phase of current or voltage desired.

On the other two panels are mounted relay cases containing the small supervisory relays similar to those at the substation under control. These relays will connect the control key on the bakelite plate representing a circuit breaker to the corresponding interposing relay at the station under control. Operating impulses from this control key then will operate the breaker which the key represents.

The cable between stations is an 11-pair No. 19 solid-copper, paper-wrapped, lead-covered cable. Only four of the wires are used for supervisory control. Two more wires are used for telephone communication. There are 11-pair cable junction boxes at each station and 26-pair junction boxes are inserted in the cable approximately every 4,000 ft. to facilitate location of cable trouble. At each station the cable is connected to the supervisory equipment through 4-kv., 3-amp. porcelain fusible disconnects of the same type as used on the primary of distribution transformers. The wires to the equipment also are connected to four protector bulbs designed for this purpose. The bulbs contain four carbon knobs within a vacuum. One of

* Part of report of automatic substation subcommittee of electrical apparatus committee, Engineering Section.

these knobs in each bulb is connected to ground and the others to the line wires. If the voltage on the line wires rises higher than 500 volts above ground potential a discharge will occur across the knob gaps within the vacuum bulb.

To maintain a supervisory control station requires the services of one man and a helper for a half-day twice a week. They are required to inspect all working apparatus, wind recording meters and renew charts, check station battery voltage and keep the station in clean condition and working order. Once a week they inspect the supervisory equipment thoroughly. Every supervision position is tested for correct indications, every metering position checked for correct reading and every control position checked up to the interposing relays. Once every two months the relay contacts are cleaned with a thin abrasive tool especially manufactured for these and similar types of relays.

Operating Methods and Routine*

It has been the program of this subcommittee for the year 1928-1929 to study the functioning of the operator in the power house, switching station or substation after he is on the job. In line with this purpose representative material was collected from the various operating companies showing the results of their endeavors in the way of standard operating codes, operating orders or whatever designation the company in question might use. Material also was obtained showing the endeavors of the various companies in the matter of educational work among the operators after they were on the payroll.

MATERIAL and information collected shows that many companies have well-worked-out operating codes, in some cases combined with safety rules and general rules which cover both operating and construction activities. Informative material such as manufacturers' bulletins, one-line diagrams and special drawings with instructions for operation and maintenance of equipment are liberally furnished for the guidance of the operator.

The work of this subcommittee shows also that the larger companies recognize the need of and have set up and maintain systems of educational work among the operating forces. Some companies make certain portions of this work compulsory while other portions are left to the initiative of the men. Certain Eastern companies from which this subcommittee obtained material have gone much farther in educational work than Pacific Coast companies, and this subcommittee believes that the value of such work is only beginning to be recognized by the Western utilities.

Functioning of the Operator

It is recognized that many matters pertaining to the successful operation of electric generation and distribution systems and the giving of proper electrical service are dependent upon the operator. His, in many cases, is an uneventful routine for many weeks at a time and then in a fraction of a second things "break loose," never twice just alike. The operator is required to size up the situation from the indications available, make his decision and act—all in the matter of seconds. On his judgment may depend human life, possible damage to thousands of dollars worth of apparatus and always to some extent the length of the interruption to service on some portion of the system. And he must make no mistake even though many of the real facts in the case of trouble do not come to light for hours or days.

Who is there that is acting or has acted in a supervisory capacity having to do with operating a power system, who has not sat at a desk the day after a case of trouble with all the facts gathered from numerous sources before him and criticized an operator for failing to see a better way to have handled the trouble in question? And has not this criticism been at times severe and cutting, even though if the critic had been on the job he might easily have made the same mistake in judgment? Again, how often have operators been given even the slightest bit of praise or encouragement for things well done? Also have the operators been given all the necessary facts, instructions, maps, wiring diagrams, etc., to enable them to understand properly their station equipment and the relation of the station to the other parts of the system?

With just this situation in mind a working outline has been prepared and used as the basis for obtaining information from the various operating companies in the P.C.E.A. Response from members of this committee has been gratifying and it is interesting to note, in studying the material submitted, the similarity in practices of the larger companies throughout the state.

Operating Codes

All companies reporting have or express an intention to have an operating code that will set up methods of handling certain operations, define such matters as clearances and other functions by whatever name they may be known, and establish the rights and duties of certain groups of employees in the operation of their system. The larger companies have well-defined operating codes that have been prepared from experience accumulated over a number of years. These codes are revised regularly and kept up to date as may be found necessary.

The operating code of the Pacific Gas and Electric Company under the title of "General Operating Instructions" is particularly worthy of comment. This code was issued originally June 21, 1911, and has been revised continuously, the last revision dated September, 1925. In addition to this the company has its "Safety Rules" for employees engaged in electrical construction and operation. This is issued in the form of a neat pocket-size booklet bound in black leatherette. Each employee is given one of these rule books and signs a statement that he will familiarize himself with and observe the rules contained therein. The book contains a general rules section and sections covering each branch of the company's activities. While the book is compiled largely from the standpoint of Safety First, it contains much material having to do with the details of operation.

The Southern California Edison Company has combined its general operating instructions with its safety rules in a booklet for employees engaged in construction and operation and bearing the title "Accident Prevention Rules and General Instructions." This book also contains organization diagrams of the company's operating department and construction department, giving the employees an understanding of "who's who" in the company. This book of course is supplemented by much detail material relating specifically to operation.

Worthy of particular mention is the Edison company's well-worked-out plan of handling all orders, rules, instructions and other matter so that an operator going from one station to another may know exactly where to find any information he may need. Another excellent plan has been worked out by the substation department whereby each station chief is required to work up a detailed set of bulletins for his own station. The subjects for these bulletins and their general scope are set forth in the plan and the bulletins must be submitted to the division superintendent for approval. This

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* Report of operating methods and routine subcommittee of electrical apparatus committee, Engineering Section, H. H. Cox, chairman. K. B. Ayres, Francis Curtis, R. C. Denny, C. B. Judson, A. P. Sessions, T. W. Snell, A. E. Strong.

plan is believed to be of particular value in developing the latent capabilities of station men.

The Los Angeles Bureau of Power and Light covers the operating code field with a series of "General Orders" and a series of "Operating Orders," applying to all stations both generating and distributing, and two series of "Operating Instruction Bulletins" applying to generating and distributing stations respectively. Standardization of station design has greatly simplified the preparation of these orders and instruction bulletins. The entire field is reviewed annually and any detail changes found necessary are made in revised issues. Station files are checked periodically to make sure that each station has all the orders, bulletins and other material it should have and also that dead material is eliminated.

Miscellaneous Informative Material

It is the standard practice of all companies to furnish one-line diagrams of the stations to operators and those immediately connected with the operation of the system. Most companies furnish a selected set of wiring diagrams and conduit prints to be kept in the station concerned. This committee has not endeavored to ascertain to what extent these wiring diagrams are corrected as small changes and additions are made to the station, but it is realized that a weakness exists on this point.

Several of the companies furnish to each attended station a selected set of manufacturers' instruction books and bulletins, and it is worthy of note that several companies comment favorably upon the value of this material which is furnished freely by the manufacturers. One company furnishes to operators and maintenance crews a set of diagrams of semi-automatic and automatic equipment showing step by step each operation in such a manner as to enable anyone at all familiar with that type of equipment to trace rapidly through the operation of that equipment. The various interlocking circuits used are shown in colors and as many sheets are used as may be necessary to show very clearly each step.

Special instructions covering many points on both routine and emergency operation are furnished by practically all the companies, generally in letter form or letter-size blueprints. A noticeable tendency for the use of letter-size blueprints, wherever possible, for matters pertinent to operation is seen in the reports. This, of course, is to enable filing of this material in ring or similar binders for more ready reference.

Instructions Posted

Instructions most generally posted in the stations are fire rules, street lighting instructions, storage battery instructions and piping diagrams. The thoroughness of several companies in posting fire-prevention rules and the enforcement of these is worthy of comment. Bulletin boards are used by some companies, but there is a decided tendency noted to restrict or eliminate their use as detrimental to good housekeeping. Several companies reporting have inspection methods which cover the point of eliminating dead material from bulletin boards and files. One company admits that the keeping of the bulletin boards and files free of dead material is a difficult problem.

Educational Work

Several of the larger companies are doing systematic educational work among their station operators along the lines of their particular operating duties. In this work use generally is made of the questionnaire method, a new operator being expected to familiarize himself sufficiently with the station and its equipment within from one to three months to enable him to answer the questionnaire. Some companies also are carrying on educational work along purely theoretical lines, having prepared courses using selected portions of such books as Croft's "Practical Electricity" as a text.

Problems relating to parts of their own particular system are used to increase the interest of the employee in the course. Other companies do not maintain educational courses of their own, but encourage their operators to take up correspondence courses. Those companies having systematic educational work for operators are, in all cases, well pleased with the results obtained. It is recognized, of course, that much of the initiative in any educational work must come from the employee himself.

At least two companies conduct periodic meetings of operators at which "papers" are read and discussed and speakers are presented to talk upon technical subjects or matters of company interest. One company holding such meetings once a month, one in the afternoon for the night-shift men and one in the evening for the day-shift men, has an average attendance (on their own time) in excess of 55 per cent of all the operators within reasonable traveling distance. Many matters directly pertaining to operation are discussed thoroughly in these meetings and a marked improvement in many ways is noticeable as a result.

Developing Initiative

An excellent example of the possibilities of developing the initiative of operators is seen in the work of the Southern California Edison Company wherein the company has undertaken to prepare a series of semi-technical papers covering the various apparatus used in its stations. Subjects are assigned to certain selected operators upon which they are asked to write a paper—for example, "Three-Phase Induction Voltage Regulators." Operators are requested to write these papers from the practical point of view dealing with the principles of operation, inspection and maintenance and giving only enough theory to describe clearly the action of the equipment.

Several men are asked to write upon the same subject and these different papers then are co-ordinated in the office of the division superintendent and from them is produced a practical paper written in language which the operator will understand. This method has the practical effect of making the operator feel that he has had a part in the workings of the affairs of the operating department above that of simply routine duties. One other company has used a somewhat similar procedure by asking individual operators to prepare papers on operating subjects for presentation at operators' meetings. Such papers invariably bring out a very lively discussion and the man presenting the paper must be prepared to reply to the points brought up in the discussion.

Fire and Resuscitation Drills

Only one company reports having organized fire drills, but several report having resuscitation drills. The value of these cannot be too highly stressed.

Errors in Operation

All reporting companies endeavor to profit by errors in operation, but methods vary. In some cases the superintendent discusses the error with the operator who made it, while others report the discussion of operating errors at their various operators' or chief operators' meetings. It is the thought of this committee that discussing the error with the one man concerned will not prove as profitable as a general discussion at some form of meeting. The latter method will result in a wider knowledge of possible errors and facilitate prevention. This can be done in such a way that no particular discredit will reflect upon the man concerned.

All companies require the repeating of all orders received over the telephone to prevent possible errors. Few companies, however, make use of written switching

orders. It is realized, of course, that written orders can be used only in larger stations where more than one man is on duty. Those companies using written orders of any form are united in approval of the method as a safeguard against errors.

Maintenance Work by Operators

The question of the use of operators in repair and maintenance work is one of considerable interest. The majority of the companies of the state do not seem to consider that the operator is in any way a repair or maintenance man except for very minor troubles. Such operations as the care of pumps, replacement of carbon brushes and fuses, care of control batteries and care of water softeners are considered normal functions of operators. Minor maintenance work such as painting equipment and floors, also frequently is done by the operators.

All companies seem to consider that for any major cases of apparatus trouble a regular shop or maintenance crew will be better qualified and equipped than the operating force. Isolated stations such as hydro power plants usually are expected to do more maintenance work than substations. It must be realized, of course, that the limiting of the operator to strictly operating duties and the calling of a maintenance crew for every small repair job has a decided tendency to destroy the initiative of the operator.

Advancement of Operators to Other Work

The question of advancement of operators to positions other than the normal advancement as an operator is nicely covered by a report which is quoted herewith:

"It probably is true to a certain extent that the confinement of an operator's position does not bring him forcibly to the attention of other departments. However, any employee may apply through the personnel department for transfer to other lines of work and such applications always are given proper consideration.

"Every effort is made to advance capable men to more desirable positions in their own or other departments. The fact that many employees in maintenance and service work, in shops, in the sales department and in responsible office positions have been station operators is an indication that capable aggressive operators do have opportunity for advancement."

Conclusions and Recommendations

All companies have covered the field of an "operating code" to fit their own particular system in their own peculiar manner. The resulting material and its nomenclature are widely at variance, but it is doubtful if much could be accomplished in the way of standardization.

The value of educational work among operators has barely begun to be realized. Its possibilities, of course, are not limited to operators, but as the operators are directly concerned with the giving of 100 per cent uninterrupted and satisfactory service to the public they, of all employees, must know their job. It is the recommendation of this committee that further study be given this subject.

Protective Relays—New Developments and Troubles*

SPECIFICALLY, the subjects included in the activities of the relay subcommittee and reported upon herewith include:

—New developments and new applications.
—Difficulties with relays.
—Difficulties with relay circuits.
—A study of relays in connection with automatic or remotely controlled stations.
—Methods of determining relay settings.
—Analysis of relay operations.

New Developments and Applications

The two larger manufacturers have put on the market within the last year twelve new types of relays known as CA, CRC, CR3, CWC, IJ11, IJ12, IC104-Y5, IA208, PY4, IC104-Y4, I205-Y7, and I204-Y9.

Type CA is a ratio-differential relay for the protection of transformers and alternating current generators. It works on the principle that there must be a definite unbalance from normal between the current flowing into one side of the apparatus and that flowing out of the other. Thus, the relays may be set sensitively for normal loads without danger of having the relays trip out on through faults due to either faulty balancing or faulty current transformer characteristics.

Type CRC is a ground protection relay for use on grounded neutral systems and can be applied to high-voltage systems where there are no potential transformers available, providing the transformer bank neutral be grounded at the point where the relay is to be applied. The transformer bank need not be solidly grounded, it may be grounded through a resistor.

Instead of securing the directional feature from the phase relation existing between a residual current of the line to be protected and the residual voltage, both of the windings are current coils and the residual current of the line flows through one of these and the residual current of a power transformer bank flows through the other. Since these currents are very nearly in phase it is possible to secure correct operation of the directional element regardless of the phase relation existing between the voltage and current on the system during a fault. Since the relay is connected only in the residual circuits of current transformers where there are no currents under normal conditions, the relay settings may be made for values much lower than the normal full load current.

Type CR3 is a polyphase directional relay for transmission line protection and consists of three directional elements mounted in a single case and acting on a common shaft. The relay has been designed for the so-called "90 deg. connection," that is, the use of phase A current with phase BC potential.

Type CWC is a directional residual relay designed for ground protection on systems operating with grounded neutrals on all transformer banks. Its application does not require the use of potential transformers to secure directional control. This relay differs from the usual directional relay since instead of depending upon a separate directional element operated by both current and voltage, the directional feature is incorporated in the relay by taking advantage of the relative direction of the residual currents flowing in the lines to be protected and in the power transformer bank neutral. The relay has two current windings one of which is connected in the secondary residual-current circuit of the line current transformers while the other is connected in the secondary of a current transformer in the neutral of the power transformer banks. The phase relation between the residual currents applied to the relay is such that faulty operation of the directional feature is impossible and the induction element will not rotate in the tripping direction unless the fault current flows "out" on a line which the relay is protecting.

Type IJ-11 is a differential current relay for the protection of transformers having three sets of leads,

* Report of relay subcommittee of electrical apparatus committee, Engineering Section. N. P. Carlsen, Jr., chairman. J. C. Alberts, Frank Ayres, G. M. Babcock, J. E. Bridges, R. C. Denny, A. S. Glasgow, E. W. Rockwell, A. Scott, J. F. Spease.

internally. There may be three separate windings or two windings, one of which has a tap. The relay has two discs on a common shaft actuated by three restraining elements and one operating element. The three restraining elements are connected to three current transformers in the power transformer circuit. The current transformers are connected so that under normal operating conditions the resultant current is zero, but when a fault occurs the equality no longer exists and current flows through the operating coil of the relay which forms part of the common return to the current transformer. When this current reaches 25 per cent of the main current, the relay functions.

Type IJ-12 is an induction relay for the protection of load ratio control units. This relay has three single-phase units in one case, each unit having one restraining and one operating element. Restraining coils are connected to the main current transformer while the operating coils are connected in the exciting windings of the load ratio control unit. Under normal conditions of 10 per cent buck or boost the exciting winding takes a current equal to that of the main power transformers. When this current, due to a fault, reaches 2.5 times the main current the relay will function.

Type IC104-Y5 is a network relay and is designed so that as long as the voltage is normal the relay is non-sensitive and will permit high reverse currents to flow. When the voltage drops, due to short-circuit conditions, relay becomes sensitive and will function on low value of current. The relay consists of a wattmeter element plus another coil which is wound on the same iron structure as the current coils and excited by the same voltage that energizes the potential coil. The current coils are energized by current transformers. When the direction of power is reversed the flux due to the current bucks that due to restraint until at a certain predetermined value it overcomes the restraint and closes the relay contacts thereby tripping the network protector. The relay may be used to reclose the switch also by not making use of the restraining circuit when the protector is open. The restraining circuit is opened by an auxiliary switch.

Type IA-208 is an instantaneous induction overcurrent relay developed for use primarily with the carrier-current pilot protective system. The overcurrent starting relay (IA-208) and tripping relay (IA-208-Y1) are similar in construction having an aluminum disc actuated by a high-torque driving magnet to obtain practically instantaneous operation, short disc travel to close contacts, and a cork slip clutch on the relay shaft to limit the torque transmitted to the contact mechanism and also to prevent rebound of the contacts which otherwise would occur at high currents. The tripping relay has in addition a holding coil and target mechanism and also a locking coil to hold the trip contacts open against overcurrent until a receiver relay actuated by carrier-controlled current opens its contacts and releases the locking action.

By using such relays in the carrier-current pilot protective system, the circuit breaker trip circuit is energized 0.25 sec. or less after a fault occurs in the protected section of the transmission line.

Type PY-4 is an auxiliary relay and was designed to control potential circuits of reactive kva. meters in cases in which it is desired to measure incoming and outgoing lagging kva. or incoming and outgoing leading kva. The relay is essentially an electrically operated switch having two single-pole double-throw mercury contacts. There are two operating coils suitable for momentary use on either a 110-volt a. c. or d.c. circuit.

Types IC-104-Y4, IA-205-Y7 and IA-204-Y9 are new network relays. The first mentioned is a power-directional relay, the second is an overcurrent, and the third an overvoltage relay. The three relays are used as a relay combination which is not sensitive to small reversals of power, but which trips quickly on transformer or feeder faults. The operating coils of the power-directional relay are connected to a special current transformer. Upon a reversal of power the power-directional relay closes its contacts connecting the operating coils of the overcurrent relay in parallel with its own current coils so that both relays are energized by the same transformer.

Due to the design of the operating coil of the two

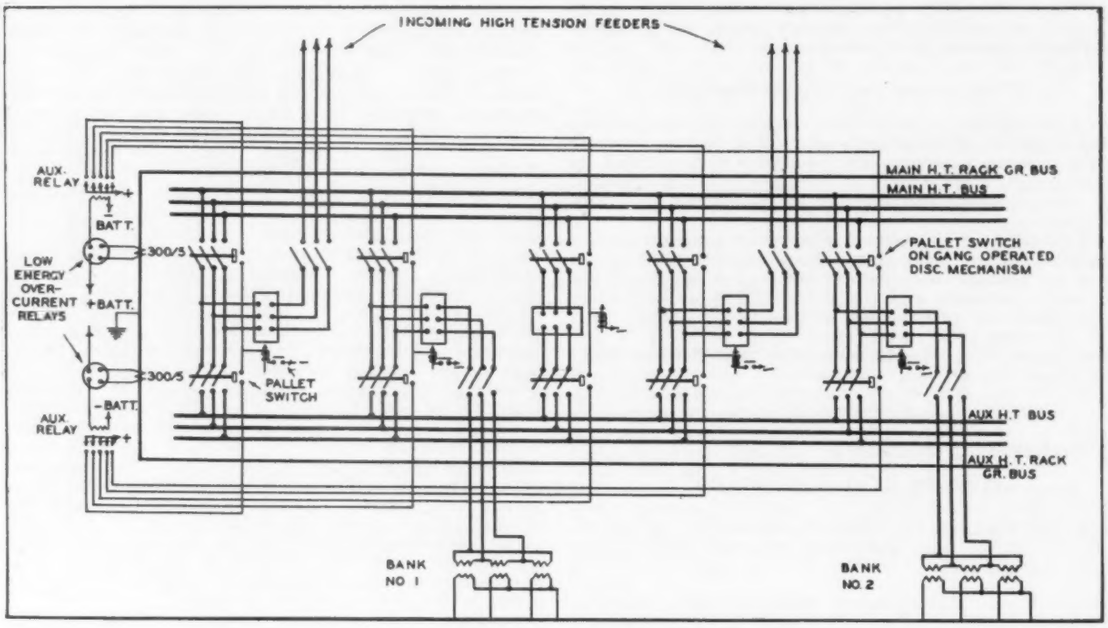

Fig. 1. A station bus ground-protection system.

relays, practically all of the current flows through the overcurrent relay. The overcurrent relay can be set to operate at any current from 75 to 1,000 amp. and its operation trips the network protector. The network protector will remain open until the overvoltage relay, which can be set to any predetermined value, operates and recloses the network protector.

A Type CZ-CRC combination relay has been developed by The Southern Sierras Power Company for line faults and ground faults. That company is using it on its Imperial Valley 88-kv. loop.

As originally intended, the overcurrent element of the CRC relay was to be connected in the circuit common to the three current transformers in the line and the directional element in the secondary circuit of a current transformer placed in the grounded neutral circuit of the power transformer. At all points on the loop, except San Bernardino, bushing-type current transformers are used in the line breakers. When the CRC relays were connected in the prescribed manner it was found that the ratio failure of the bushing current transformers with such a heavy volt-ampere burden was so bad that the relays would respond to nothing but a very severe ground fault. This feature was very undesirable and the expense of purchasing line-type current transformers to replace the bushing-type transformers was not believed to be justified. Therefore an experiment was tried which proved very successful in overcoming the difficulty.

The CRC relay connections were interchanged, placing the directional element in the bushing transformer circuit and the overcurrent element in the transformer grounded neutral circuit. The directional element was found to respond to low currents readily in this arrangement and the overload element could be set as desired with no trouble due to current-transformer ratio failure. Using this method of connection, it was found that the CRC relays would respond readily to a ground fault of as little as 10 amp. (primary). The success of these relays is summarized later in the analysis of relay operations.

Station Bus Ground Protection.—The San Joaquin Light & Power Corporation has developed bus protection consisting of separate sets of CO relays in differential connections involving the current transformers of all line and transformer switches. The outgoing power is simply balanced against the incoming power. These installations, some ten in number, are working entirely satisfactorily.

The Los Angeles Gas & Electric Corporation has developed a bus ground protection and a bus differential alarm which are described in the following paragraphs.

The 16.5-kv. buses in some substations are mounted exposed on a metal rack and practically all short-circuits on these buses involve one phase to the grounded rack. By grounding the rack through a current transformer and insulating the rack from all other grounds a phase-to-ground short can be cleared by the current passing through this current transformer the secondary of which is connected to a relay which trips all circuit breakers connected to the bus. The selection of proper circuit breakers to be tripped is made by a pallet switch on the mechanism of the gang-operated bus disconnects.

Figure 1 shows a wiring diagram for this type of protection. With a condition as shown one feeder and one transformer bank can be closed to the main bus and one feeder and one transformer to the auxiliary bus and the bus tie switch closed to both buses. Then a ground on either bus will open all switches the related disconnects of which are closed to the faulty bus, but will leave in service the one feeder and transformer connected to the good bus. The relay on this type of protection does not have to be cascaded with the time setting of any other relay and therefore can be set to trip in as short a time as desired.

In the first two stations equipped with this protection the pipe rack was fastened to the concrete with bolts, care being taken to keep bolts away from reinforcing rods in the concrete. In these cases twenty ohms resistance was observed between rack and ground, with the current transformer disconnected. In later installations fiber tubes and washers were used around the bolts supporting the rack. In these cases a resistance of 500 ohms was obtained between rack and ground with the current transformer

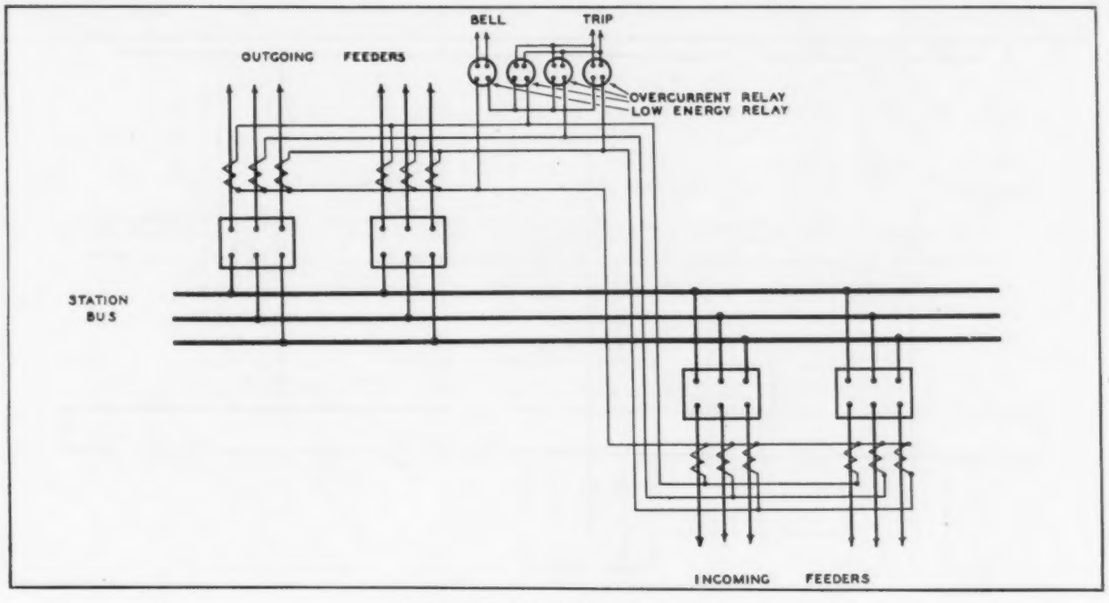

Fig. 2. Bus differential alarm system.

disconnected. With actual minimum short-circuit conditions a 16.5-kv. grounded bus was cleared in 0.5 sec. total elapsed time.

Bus Differential Alarm.—Figure 2 shows a low-energy overcurrent relay inserted in the residual circuit of a bus-differential protection scheme. This relay is used to sound an alarm when the bus-differential circuit has a flow of current too small to actuate the tripping relays, but which may increase to tripping value when there is a short-circuit on some other part of the system causing a heavy flow of current through the station bus. Such a small current flow in a bus-differential circuit can be caused by open current transformers, poor contact in pallet switches, faulty secondary wiring, and other similar things.

A serious outage may be forestalled by this simple alarm.

Transformer Bank and Secondary Bus Protection with Feeder Circuit Backup Protection.—There are cases where two or more transformer banks have their secondaries connected together through reactors in a ring system. The feeders connected from these bus sections, having reactors in their circuit, have a limited short-circuit current below the normal load of the combined transformer banks. With the ordinary transformer differential and overload scheme of relaying, the feeders are without backup protection in event of failure to trip in time of trouble.

Figure 3 shows a single-line diagram wherein the currents feeding into a transformer and its bus section are added together. This gives sufficient current in the overcurrent relay to clear the bus section in time of short-circuit on a feeder if that feeder fails to trip out correctly. With this form of protection a short-circuit in a transformer or its secondary bus section will operate the relay which will clear that section of the station leaving the other transformer banks and their feeders in operation.

If a flow of current is passing into a bus section and then out to another bus section the secondary current caused by this flow in the current transformer at the incoming end will be vectorially subtracted from the secondary current caused by this flow in the current transformer at the outgoing end of the bus. Therefore a flow of current passing into a bus section and out to another bus section will not effect the relaying of this first section.

It is possible with certain transformer bank primary-to-secondary current ratios to secure a standard current transformer for this system of protection which will make the use of current-balancing transformers unnecessary in the relay circuit.

Reverse Power Protection Over Supervisory Control Cable.—With a number of substations connected to a generating station and to each other either by a loop or through a conglomerated network of transmission lines, it is necessary to cascade the relay settings in order to hold in the lines nearest the generating station for a time sufficient to allow the most distant lines to clear in event of short-circuit in those distant lines. With this condition the lines nearest the generating station are held in for the longest time in case of short-circuit whereas they have the heaviest short-circuit currents and should be cleared rapidly.

To eliminate the necessity of cascaded relay settings the protection scheme as shown in Fig. 4 is suggested for installation where spare wires are available between two stations, as may be the case where supervisory control is in use. It is necessary that the outlying station have a source of supply in addition to the line to be relayed. The ordinary form of loop-line relaying is retained to be used as a backup protection, that is, overcurrent and ground protection at the end nearest the generating station and overcurrent and ground in series with reverse power really at the further end.

In case of short-circuits on the high-line, current flows in from each end of the line and the relay operations are as follows: At the station closest to the generating station the reverse-power relay and fast-time overcurrent relays close their contacts and at the outlying station only the reverse-power relay closes its contacts. Thus 125 volts d. c. from the outlying station battery is connected through the reverse-power relay contacts, through the supervisory control relay winding, out over the wire to the other station where it passes through the supervisory control relay winding at that station, through the reverse-power relay contacts, through the fast-time overcurrent relay contacts and back over the wire to the outlying station battery. This causes the supervisory control relays at each station to operate and trip their respective oil circuit breakers.

The fast-time overcurrent and ground relays are

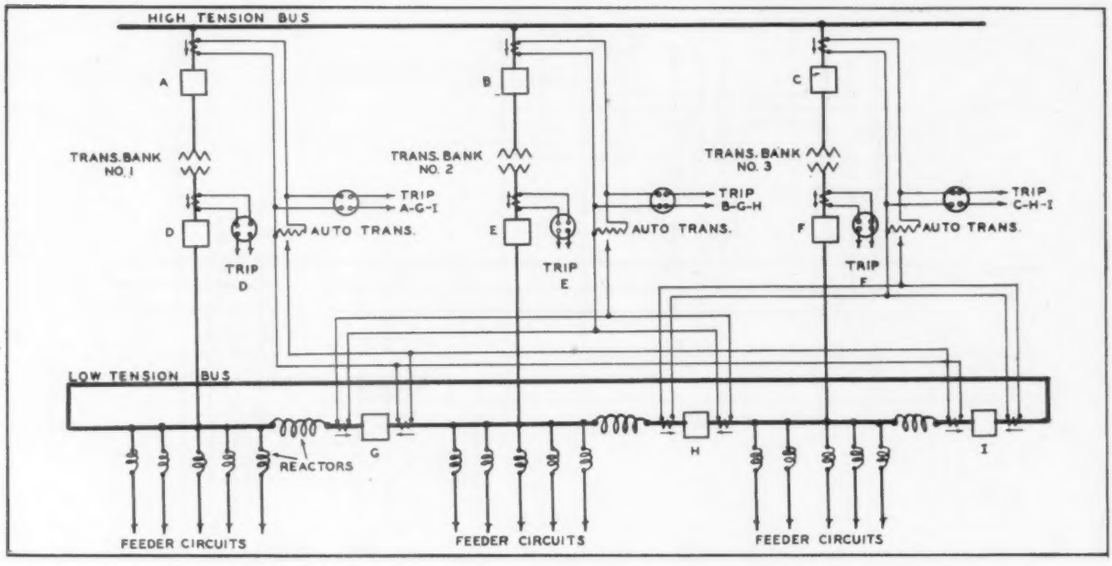

Fig. 3. Transformer bank and secondary bus protection with feeder circuit "backup" protection.

used in this circuit in order to have just enough time element to avoid the possibility of a trip-out should both reverse-power relays have their contacts closed at the same time for an instant, as may be the case in time of a sudden reversal of power through the high-line caused by a short-circuit on some other line beyond either station. They are installed at the station closest to the generating station because that station furnishes the heaviest short-circuit current and also because the reverse-power relay at that station is normally closed, thus the overload relays keep the line wires open at the end. Relaying wires between stations are equipped with the same type of line protection as commonly used on supervisory control wires.

The Los Angeles Bureau of Power & Light has developed a new application for an undervoltage relay. It is used to prevent closing the bus grounding switches to the high tension buses by interlocking the switches. It is connected in such a way as to prevent closing the switches as long as the buses are energized.

Section 2

Difficulties With Relays

A majority of the companies report trouble due to contacts closing simultaneously and troubles caused by poor operation of indicators. These troubles are inherent in the various relays and can best be overcome by the manufacturers.

One company has installed annunciator systems in place of operation indicators. Another company reports that it is having difficulty in testing relays due to crowded boards and congested arrangements of studs. This company suggests a method of removing the relay from the panel. Two companies continue to report trouble with directional overload relays due to surges.

Section 3

Difficulties With Relay Circuits

Most companies report pallet-switch troubles. The main trouble seems to be due to dirty contacts and poor mechanism. It is recommended that the manufacturers of various breakers endeavor to develop a pallet switch which will be positive under all conditions. Several of the companies report trouble due to faulty insulation of the bushing-type current transformer. This can best be overcome by the manufacturers.

One company reports a peculiar case of trouble which occured on a set of differential-current relays with pilot wires which were installed to protect a cable. At the time the system was installed a solid ground to the station ground bus was installed from the neutral of the resistors at one station and the other station was connected the same except that a lead film cutout was inserted in the wire. With the relays installed in this manner the only insulation between the two station ground buses was the lead film cutout. Consequently, during a case of trouble near one end of this cable the voltage of one station ground bus was raised considerably above the other and the lead film cutout punctured. This allowed a portion of the ground current to return over the pilot wires and caused the relays to operate at both ends when the cable itself was not in trouble. It was then decided that by removing the ground from one end entirely and leaving the lead film cutout at the other end this trouble could be stopped. However, this was not the solution as the station ground at the ungrounded relay end was raised to such a potential that it broke down to the relay current wiring in a conduit and caused false relay operation again.

There are at least three ways to cure this trouble, but only one seems to be the logical one. One way would be to tie the two station grounds together with heavy copper. This would be too expensive. Another

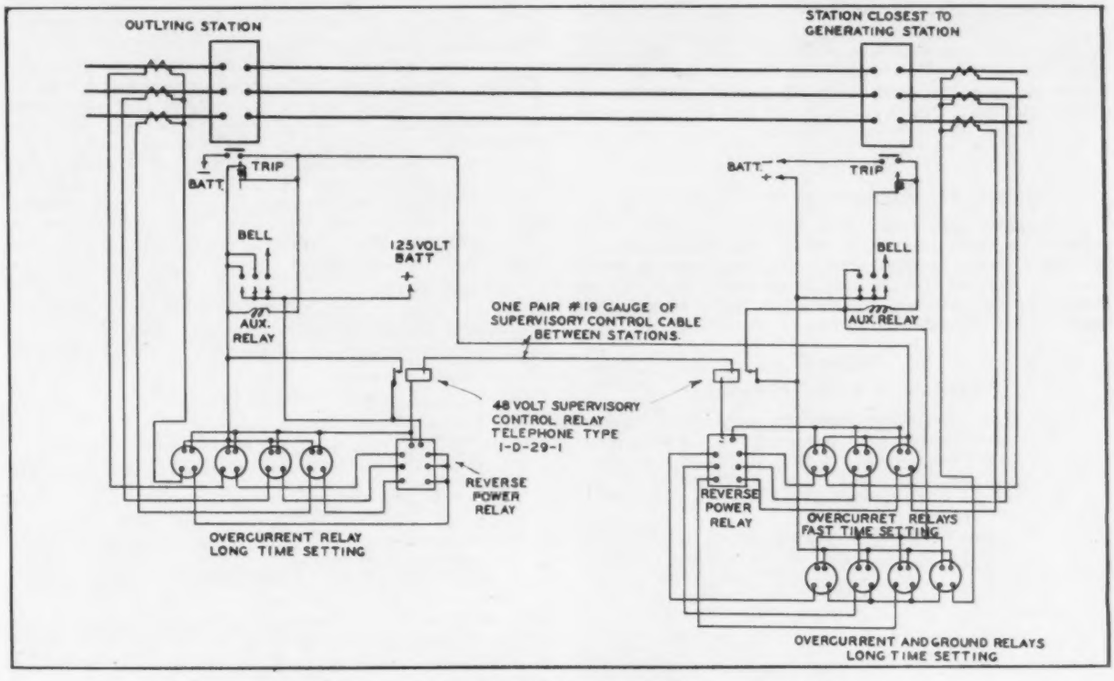
OUTLYING STATION
STATION CLOSEST TO GENERATING STATION
BATT.
TRIP
BELL
125 VOLT BATT
AUX. RELAY
ONE PAIR #19 GAUGE OF SUPERVISORY CONTROL CABLE BETWEEN STATIONS
48 VOLT SUPERVISORY CONTROL RELAY TELEPHONE TYPE 1-D-29-1
REVERSE POWER RELAY
OVERCURRENT RELAY LONG TIME SETTING
OVERCURRET RELAYS FAST TIME SETTING
OVERCURRENT AND GROUND RELAYS LONG TIME SETTING

Fig. 4. Reverse-power relay protection over supervisory control cables.

way would be to insulate the relay wiring for extra high voltage. This again would be somewhat expensive and would still leave one end of the relay system ungrounded. The best solution seems to be to put 1/1-ratio insulating transformers in the pilot wires. This would allow the relay wiring to be grounded at both ends and would prevent ground currents from returning over the pilot wires.

Section 4

Study of Relays in Connection With Automatic or Remotely Controlled Stations

The Los Angeles Gas and Electric Corporation has three substations under supervisory control. One of these stations has been in service for a year and has not had a case of trouble which could be attributed to any mechanical or electrical feature of a relay.

The Los Angeles Bureau of Power & Light has three supervisory-control substations on its system which have reclosing mechanism on the outgoing radial feeders. With the exception of a few cases of contact trouble, their operation has been entirely satisfactory.

From all of the reports submitted the indications are that before another year expires automatic stations will be in use on practically all of the power systems in California. The larger systems now have some semi-automatic, some fully automatic and some supervisory-control stations all of which are working entirely satisfactorily.

This being something of a new line of endeavor the various companies are not in a position to go much into detail. One of the companies recommends the development of a supervisory control relay which would have an adjustable time operation feature of from 1 to 10 sec. Another company recommends the development, for automatic and remotely controlled stations, of a contactor of compact construction similar to the HG type, but provided with two parallel or two independent circuit contacts. If such a contactor could be built to have but slightly larger dimensions than the present single-pole units, much switchboard space could be saved where several contactors were used. Another desirable development would be a similar 1- or 2-pole contactor designed to have the contacts closed when de-energized and open when energized. Compact contactors of these types designed to carry only the small currents required certainly would be desirable and the suggestion is passed on to the manufacturers.

Section 5

Method of Determining Relay Settings

This particular suggestion did not receive much support in that practically all of the companies are using the same method, one which has been in effect for the past several years. Apparently the various companies are entirely satisfied and there is but little hope of finding new methods.

Section 6

Analysis of Relay Operation

There seems to be no standard method of analyzing relay operations. Each company has its own ideas and this committee suggests that an effort be made to provide a standard report for all companies. From the analysis of the various reports, relay operation seems to be entirely satisfactory.

One company reports that out of a total of 98 relay operations there were 10 incorrect. Another company reports that out of 1,536 operations there were 76 undesirable, 2 incorrect due to the relay, and 6 incorrect due to auxiliaries. The percentage of correct operations was 95. Another company reports that out of 282 operations, the service was 99.995 per cent continuous. Another company reports that out of 63 cases of relay operation 93 per cent were correct. Of automatic switch operations, out of 187 relay operations 100 per cent were correct. Another company reports that out of a total of 19 faults on its transmission system there were 172 relay operations 13 of which were incorrect, two of them due to relay settings and eleven to the relay scheme. On that same company's distribution system it is reported that out of 264 faults involving 747 relays there were 10 incorrect operations, 7 due to relay settings, 2 to troubles inherent in the relay, and one to the relay scheme.

From the foregoing it may readily be seen that the relays as a whole are very reliable instruments. There are a few cases where trouble has occurred to apparatus and which still leave room for improvement.

This committee suggests that for the coming year the relay work be devoted practically in its entirety to the automatic stations.

Switchgear*

This report consists of a review of the reports submitted by the committee members representing both manufacturers and operating companies.

The report is divided into four sections: (1) Oil Circuit Breakers, (2) Disconnecting Switches, (3) Fuses, and, (4) Comments by operating companies. Each section is published in the following pages under its own heading.

In the first three sections new developments, improvements and changes are brought out from material submitted by committee members representing manufacturing companies. The last section is composed of discussions received from members affiliated with operating companies. The discussions by operating company members cover the same subjects which members from manufacturing companies have reported upon.

FOR several years past the subcommittee on oil circuit-breakers has reported upon that equipment exclusively, but it was proposed that this year the program of the committee should be expanded somewhat and other sub-topics included. The designation of the committee therefore was changed to that of "subcommittee on switchgear." Two main topics, disconnecting switches and fuses, have been added for discussion and the following outline of subjects has been used as a guide:

1. **Oil Circuit Breakers.**
   - (a) New types
     - High tension
     - Low tension
     - Motor operators
     - Solenoid operators.
   - (b) Application
     - Methods of installation
     - Control wiring
     - Arrangements for inspection
     - Means of isolation by use of bypass and disconnecting switches
     - Periodic inspection and mechanical testing
     - Oil testing and handling.
   - (c) Operation
     - Difficulties encountered
     - Suggestions for breaker improvements.

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* Report of switchgear subcommittee of electrical apparatus committee, Engineering Section. B. D. Dexter, chairman. R. E. Cunningham, A. Fulton, C. E. Ingalls, J. N. Keith, D. J. Kelly, Roy Martindale, P. C. McCorkle, G. K. Morrison, P. J. Ost, Clark Pettingill, S. P. Russell, E. K. Sadler, R. C. Stackhouse, H. M. Thomas, C. W. White, Roy Wilkins.

2. **Disconnecting Switches**
   - (a) New types (all voltages)
   - (b) Methods of installation
     - Stick operated
     - Remote mechanical operation
     - Remote electrical operation
     - Indoor barriers.
   - (c) Heating difficulties.
3. **Fuses**
   - High- and low-tension types
   - Power filled
   - Oil filled
   - Use of resistors
   - Application
     - (a) feeder circuits and transformer banks
     - (b) potential transformers.

Oil Circuit Breaker Developments*

REGARDING improvements and changes in design one manufacturing company submits the following review:

Manufacturer "A"

"With reference to high-voltage, high-capacity breakers for outdoor service the developments during the past year have been mainly toward the elimination of all except round construction. The present line of breakers from 15 to 220 kv. with interrupting ratings up to 2,500,000 kva. all have internal balanced-pressure operating mechanisms, round tanks with domed bottoms and covers and short-bolt tank suspension. Breakers of moderate interrupting capacity have plain-break wide-angle finger-and-wedge contacts, while explosion chambers with rod-and-segment contacts are used for higher ratings. (See Fig. 1).

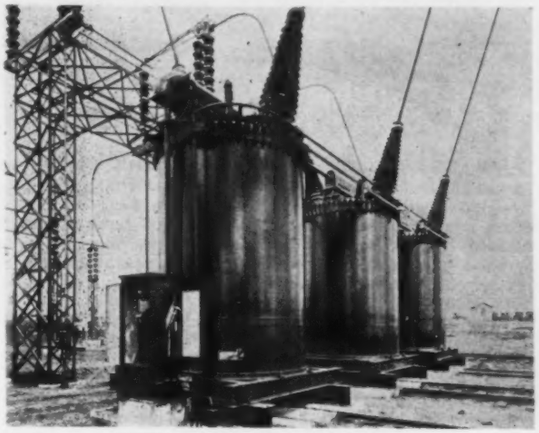

Fig. 1. 220-kv. oil circuit breaker.

"A new line of breakers for indoor service provides triple-pole breakers with all poles in a single round steel tank. These breakers are designed primarily to afford moderately high interrupting capacity in a very small space. Their design departs from convention in that these moderately rated breakers include in their construction practically all of the features which formerly have characterized only the breakers of extremely high interrupting capacity. The short-bolt tank suspension, the internal mechanism, the round tank with its domed bottom and domed cover or frame, the baffle chamber to vent the gasses, all of these factors contribute to its ample margin of safety above the conservative ratings. See Fig. 2.

"The breaker is provided with a gasketed joint between the tank and the top frame, insuring oil tightness. In this breaker the wide-angle contacts, previously mentioned, are employed exclusively. Connection to stationary contacts is made through the

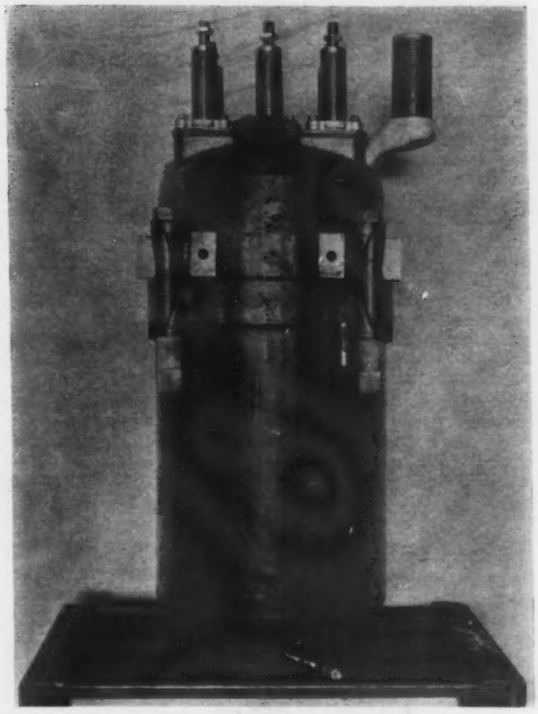

Fig. 2. 15-kv. oil circuit breaker.

studs of the solid Herkolite bushings. These bushings are individually removable from the frame. Breakers of this type are available in tank sizes from 16 to 32 in. inclusive. Ratings of 7.5 and 15-kv. are available with interrupting capacities ranging from 90,000 to 350,000 kva.

"Another breaker worthy of attention, although very much smaller than any of those previously described, is an outdoor breaker designed for either pole or framework mounting for use on 4.5-kv. distribution lines or in similar applications where the interrupting duty is not severe. This breaker meets the demand for an automatic protective device for such lines, providing reliability, ruggedness and economy. It may be manually or electrically operated in a number of combinations. See Fig. 3.

"The development of metal-clad switchgear is of particular interest and is a departure from conventional practice. This equipment is the result of a marked tendency toward the adoption of switching equipment having parts more completely enclosed, even for the largest generating stations, to insure maximum protection to operators and maintenance men, the prevention of interruptions in service due to short-circuits between bus bars, connection bars, etc., and at the same time minimize the time and cost of installation. To meet these requirements, metal-clad switching equipment for both indoor and outdoor installations has been developed.

* Part I of report of switchgear subcommittee of electrical apparatus committee, Engineering Section.

"In this equipment all buses, connection bars and main disconnecting devices are insulated for the full line voltage exclusive of the insulation value of the oil or compound with which the compartments containing them are filled. The oil circuit breakers may be raised into operating position, lowered from it or removed from the frame for inspection or adjustment by means of an elevating truck. The movable members of the main disconnection devices are located on the connection studs of the breaker while the stationary members are located in the supporting framework.

"The operating mechanism for each oil circuit breaker is mounted on the circuit breaker itself and is removed with the breaker. This makes it possible to adjust the mechanism and breaker with respect to one another. Positive interlocks are provided so that the breaker cannot be lowered from the operating position until it is open, and it cannot be raised to the operating position unless it is open. In any intermediate position it is locked against operation. Other interlocks are provided as may be required for each application to preclude improper mechanical or electrical operation.

"In the indoor equipment (see Fig. 4) the bus and transformer chambers are so designed that they can be filled with oil or semi-fluid, or solid insulating compound and for voltages of 2.3 kv. or less may be used unfilled."

Manufacturer "B"

A resume of another manufacturing company is expressed as follows:

"The complete line of outdoor large-capacity oil circuit-breakers from 15 kv. to 220 kv. has been redesigned. The new line of breakers incorporates the same general design features as have been used in the past, but with numerous refinements and improvements which have resulted from a careful analysis of manufacturing problems and field experience.

"Two materials new in circuit-breaker design are used quite extensively, heat-treated aluminum (castings and bars) and 'wood Micarta.' Both of these materials are particularly suitable with their high mechanical strength and good electrical characteristics. The moving contact assembly is made almost entirely from aluminum and weighs less than half as much as did the old form of contacts. The wood Micarta is used in lifting rods and guides in rectangular cross section and is far superior to ordinary treated wood, both electrically and mechanically.

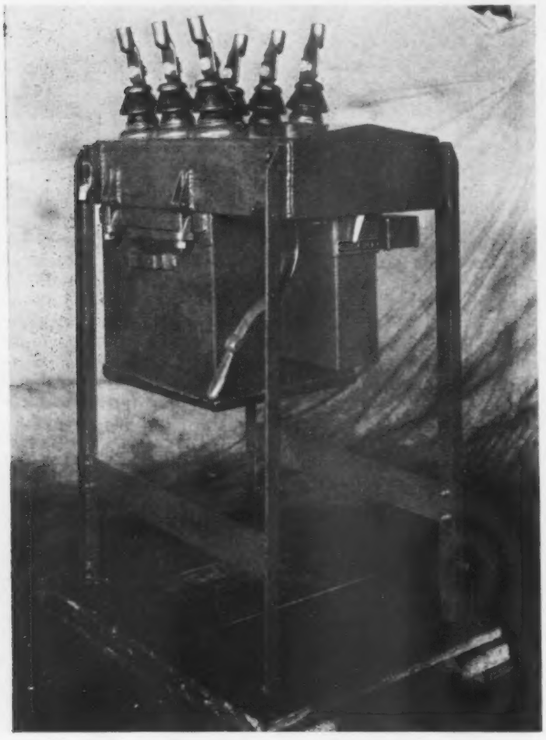

Fig. 3. 4.5-kv. oil circuit breaker.

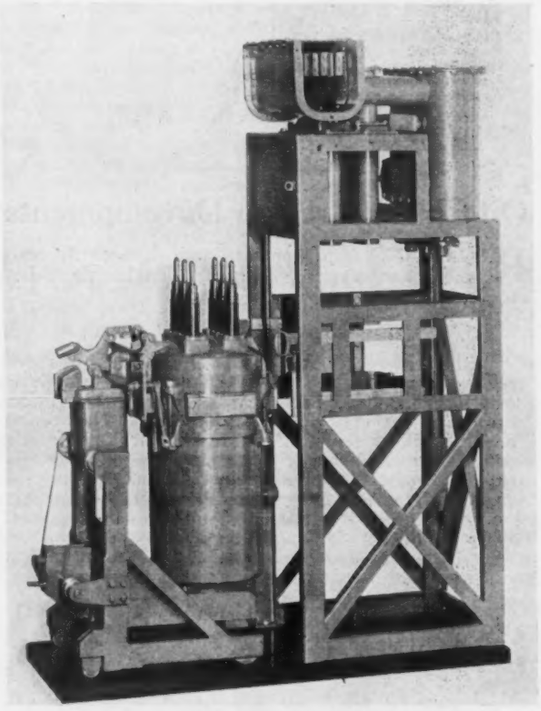

Fig. 4. 15-kv. metal-clad switching equipment.

"The new breakers can be operated by either the motor or solenoid operating mechanism. The simple and efficient pole-unit lever system is operated by means of a close-fitting, rotating shaft which effectively prevents the passage of oil or gas from one pole to the next during a short-circuit interruption. Increased length of stroke provides an ample factor of safety for the severe arc-rupturing conditions met on modern systems.

"Quick-break arcing contacts of an improved design are used in all of the larger high-voltage breakers. The very effective high-speed form of arcing contact used is shown in Figs. 5 and 6. These illustrations cover the high-speed bayonet finger contact assembly without the enclosing metal hood. Fig. 5 shows the position of the contact assembly with the breaker in the open position and Fig. 6 indicates the condition when the arcing contacts are closed and the latch is holding the arcing contact spring in full compression. An instant later the latch is released and the arcing contacts are caused to operate at a high speed. It may be noted that a spiral groove is provided which causes the latch tongue to be rotated through an angle of 90 deg. to insure a positive point of unlatch-

ing. Thus it is possible to adjust accurately the three poles of a given breaker to open their contacts at the same instant.

"The new line of breakers is provided with an oil dashpot so arranged as to bring the contacts to rest at the end of the opening stroke without any rebound. This dashpot is located under the minimum oil level

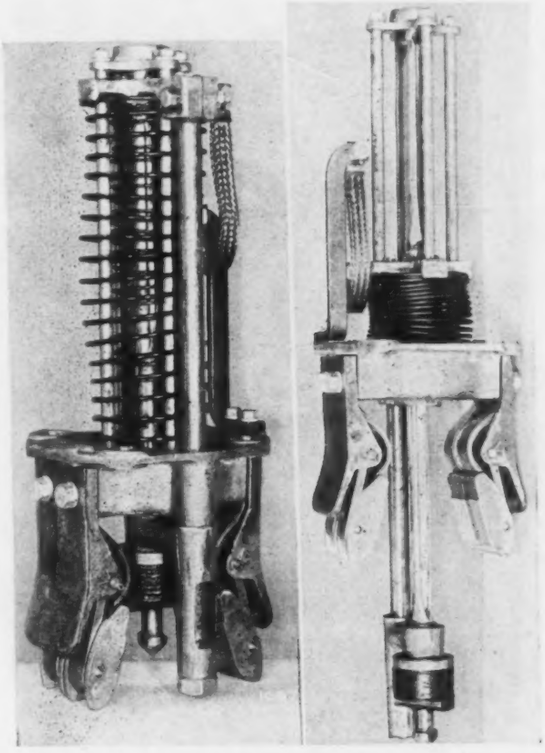

Fig. 5. High-speed bayonet-finger contact without enclosing metal hood (left).

Fig. 6. High-speed bayonet-finger contact with arcing contact spring in full compression (right).

so as to require no special attention from the operating man, being always available for service when the breaker is in normal operation.

"Quite general use is made of fabricated steel construction. All breakers in the new line have new condenser bushings with taps provided for the bushing potential device on all bushings rated at 88 kv. or higher. The breaker tank or frame also is provided with means for mounting the potential device. Condenser bushings are interchangeable with transformers for 88 kv. and higher.

"Figure 7 shows a completely assembled breaker of the new design and illustrates the 132-kv., 800-amp., Type G-22A breaker with 2,500,000-kva. rupturing capacity.

"The trend toward non-oil throwing breakers in moderate power sizes is illustrated by the Types B-16 and B-20 lines. The design of this type of breaker recently has been extended by the addition of the Type B-32 line having a rupturing capacity of 14,000 amp. at 15 kv. Similar non-oil throwing operation on isolated single-pole units has been incorporated in the development of the new Types B-7 and B-8 lines.

"The new oilless circuit-breaker (see Fig. 8) known as the Deion breaker has been proved and developed to actuality. It is designated the Deion breaker from the method of breaking the circuit by very rapidly de-ionizing the path of the arc. The theory, construction and test of this new breaker were covered in three papers recently presented before the winter convention of the American Institute Electrical Engineers.

"This design is destined to be epoch-making. It is based on fundamental, scientific considerations of the action of the electric arc. It has resulted in a new conception of the phenomena of the arc and of possible ways of interrupting the electric circuit. Heretofore, the practical method of interrupting a high-voltage circuit of considerable capacity was by an oil circuit breaker. The new device, through a fundamental study and the application of scientific principles, permits this to be done by a breaker entirely devoid of oil.

"Up to the present time work has been confined to the 15-kv. class with preliminary experimental work on 25-kv. units. While application of the principle is not limited to these voltages, considerable time must elapse before higher voltages can be practically handled."

Manufacturer "C"

The development of new types of outdoor low-voltage oil circuit breakers by a Pacific Coast manufacturing company is described in the following paragraphs.

"The new Type JC-17 (Figs. 9 and 10) has been designed to meet the need for a low-voltage oil circuit breaker with rupturing capacity commensurate with established distribution circuit requirements. These breakers have separate tanks for each phase, supported on a single top member. The blade travel is horizontal, the soundness of this design having been attested by repeated tests in the laboratory together with years of successful operation. Ample clearness between live and grounded parts, generous oil depth and high operating speed give the Type JC-17 a reserve interrupting capacity over other breakers of similar size.

"In a recent operating test under actual load conditions as set up by the American Institute Electrical Engineers the Type JC-17 interrupted a "short" of more than 100,000 kva. The blade assembly is supported on and operated by a rotating member of Bakelite that has ample strength to hold up under severe mechanical and electrical stresses.

"A feature of this circuit-breaker is the interchangeable control mounted either at the end or side which permits convenience in installation and operation where space is limited. Another feature of the Type JC-17 oil circuit breaker is that it is shipped

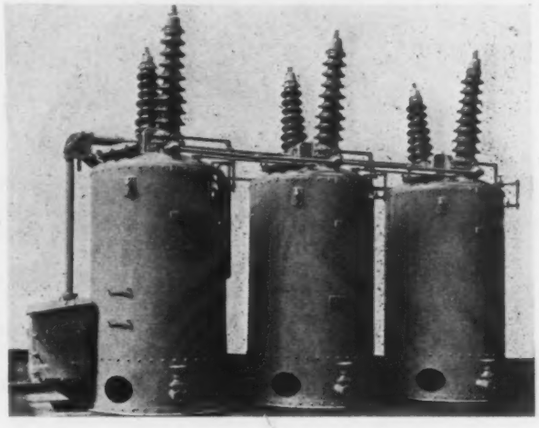

Fig. 7. 132-kv. oil circuit breaker.

completely assembled and adjusted. To place the breakers in service it is necessary only to fill tanks with oil, connect the line and control circuits and the breakers are ready for service.

"A new type high-amperage breaker has been produced. One of the important features of design on this breaker is the use of bronze for the top covers instead of the customary ferrous metal covers. Owing to the heavy current capacity, (continuous capacity to be 2,200 amp.) hysteresis loss would be an important factor if ferrous metal had been used, but with the use of a bronze cover casting this source of loss is eliminated.

"To reduce the weight of reciprocating parts and still keep the required temperature control on current carrying parts, bus-bar copper has been used wherever possible for blades, contact parts, and other related parts. These breakers are built on the rotary break principle, a design that has been proved to be efficient and correct since the first successful 60-kv. oil circuit breaker was made some 25 years ago on the principle of the rotary break. They are of the multi-break type, having four breaks in series per phase and auxiliary arcing contacts on all breaks.

"Each rotating unit has two bearings, the main bearing and bevel drive gear mounted in the top casting and an auxiliary steady bearing at the bottom of the rotating unit. This steady bearing is mounted on the cross-member that carries current across the two poles from the lower pair of series contacts. It is suspended from the top and, once correct alignment has been set in the factory, field inspections will not disturb the alignment when the tank is lowered.

"Owing to the severe climatic conditions in the region wherein these breakers are used and the necessity for keeping them in continuous service for long periods, the breakers have been insulated for 37 kv., although the normal operating voltage will be 11 kv. They are operated by Type MW motor controls, a high-speed motor-wound, spring-actuated control. This motor operator has several important operating characteristics that are essential to the successful operation of an oil circuit-breaker.

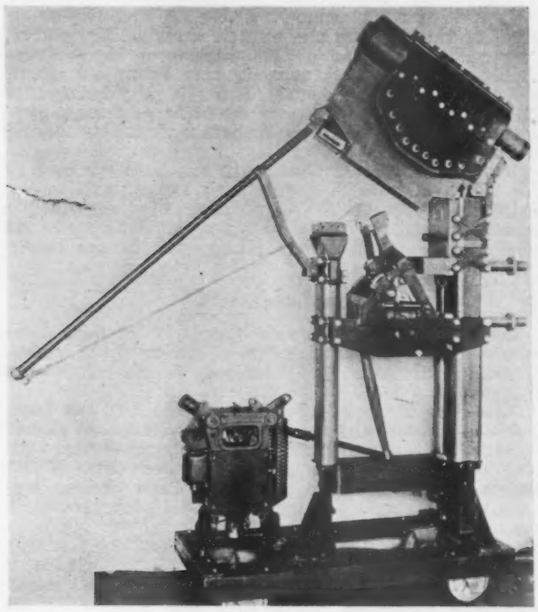

Fig. 8. Deion circuit breaker in open position.

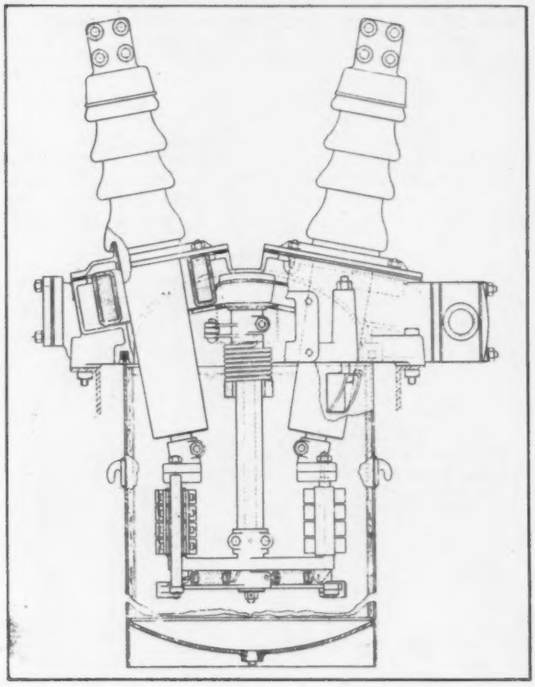

Fig. 9. 15-kv. oil circuit breaker, single-pole assembly.

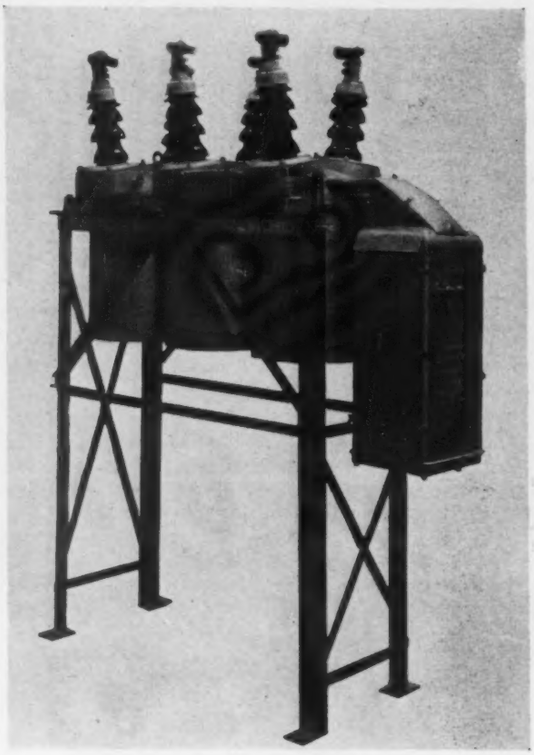

Fig. 10. 15-kv. oil circuit breaker.

"The mechanical interlocking of this mechanism is such that it can trip free at any position or stage of the control operation. Therefore it can be tripped open automatically at any time the instant that current commences to flow in the current transformer, even though the closing operation is still in progress. It is impossible to wind or operate the closing spring

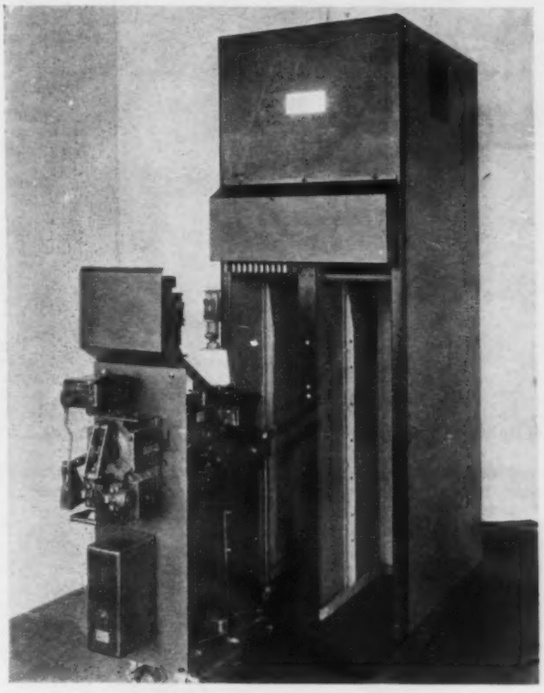

Fig. 11. Steel-clad switch gear.

without also winding the opening spring. The time of winding is from eight to twenty seconds depending upon the size of the mechanism. This set-up makes it possible to reclose any breaker that has been opened, thus making the complete cycle from tripping open to reclosing favor the "MW" control in comparison with other motor-actuated mechanisms.

"The four-stage operating cycle of this mechanism under normal conditions with the breaker closed is:

1. Release of tripping spring causing circuit breaker to open.
2. Immediate automatic winding of both opening and closing springs, simultaneously.
3. Both springs wound. Circuit breaker open and at rest.
4. Release of closing spring. Closing the breaker at will of operator or by action of reclosing relays (the opening spring being still wound to open the circuit breaker through the operation of relays or control switch, thus recommencing at [1] of operating cycle)."

Manufacturer "D"

Refinement in oil circuit breaker design by one manufacturer is described as follows:

"It has been found that if the speed of an oil circuit breaker be greatly increased above a certain balanced or effective value, the arc will be so drawn out that the oil must absorb a large part of the heat to be dissipated with resultant chemical break-down and generation of large volumes of gas. If the speed is maintained at a certain value, thereby restricting the effective dissipation area of the arc, and if at the same time very heavy arcing tips are used it has been found by actual test that more effective interruption is secured through the resultant shorter arc duration and lower pressures.

"This is because the heavy arcing contacts (when parting) absorb a much greater quantity of heat directly, thereby keeping the arc relatively cool and comparatively short, allowing but a small portion of its heat to be given off to the oil. The arcing tips then give off their accumulated heat gradually to the oil so as not to cause its breaking down. Consequently gas production is reduced. Obviously if the gas volume is reduced the pressure is proportionately decreased and the destructive effect lessened. Arcing tips of all the latest types of breakers are even larger than formerly to afford this thermal absorption feature. In keeping with the improved design of contacts, a refinement and strengthening of the oil circuit-breaker frames, tank mechanisms, bushings and supports also has been made.

"Another feature of particular interest is a new arrangement of the arcing contact circuit that is used in the new Type D and Type F oil circuit breakers. The principle of mutual attraction of currents traveling in the same direction and repulsion of currents traveling in the opposite direction is utilized to insure that the arcing contacts remain closed until the main brushes have safely parted. Perhaps the most novel development is the provision to utilize the electromagnetic forces generated in the breaker to secure a high rate of initial acceleration of the moving member. These forces assist the accelerating springs normally provided. A general application of hydraulic shock absorbers to all heavy-duty and high-tension breakers is an added detail as well as Parkerizing of all the smaller parts of high- and low-voltage breakers.

"Figures 11 and 12 illustrate a new design of steel-clad switchgear of the vertical-lift type. This view

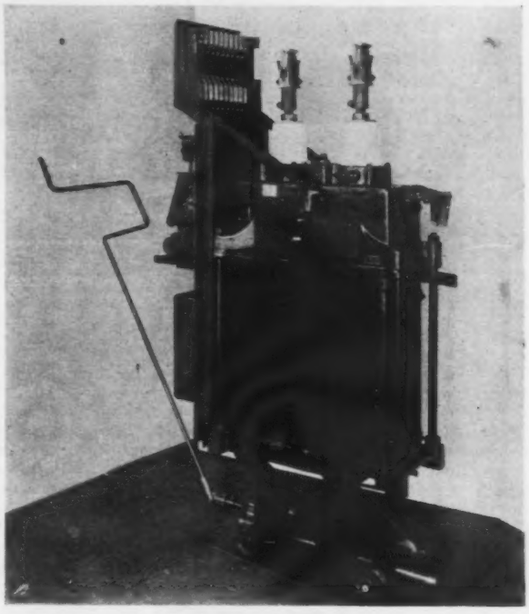

Fig. 12. Steel-clad switch gear.

shows the truck-mounted oil circuit breaker pulled out, ready for inspection. The truck may be rolled into its cell and raised into its operating position by means of a hand crank. Gas-tight barriers separate the buses from the circuit-breaker."

Disconnecting Switches*

Manufacturer "A"

A NEW type of heavy-current, triple-pole vertical mounting disconnecting switch, suitable for use up to 4,000 amp. is shown in Fig. 13. In the development of this switch the designers have made radical departure from the conventional construction of disconnecting switches in that high-pressure line contact is used at both hinge and jaw ends of the switch. The blade is supported at the hinge-end and is entirely free from contact pressure when opening and closing.

The blade of each unit consists of two parallel sections of hard-drawn copper spaced sufficiently far apart to permit a system of wedges to be inserted between them at both the hinge and contact ends. These wedges are actuated by a combination of linkages which come into action after the blade is in the fully closed position. These wedges serve to establish a high pressure between the blades and the accurately machined line contact surface on the contact blocks. A positive pressure in excess of 1,000 lb. is established between the blade and contact and this provides a most efficient path for the current with exceptionally low temperature rise.

In the opening operation of the switch the first movement of the operating handle releases the pressure at the contacts and the switch then opens freely.

Manufacturer "B"

A recent type of 220-kv. disconnecting switch appears in Fig. 14. This switch is operated through rotating the middle stacks of insulators. The rotating of these stacks operates the worm-and-worm gear above them. The first turns of the stacks result in pulling back the arm at the top of the switch thereby disengaging the contacts. Additional turns raise the

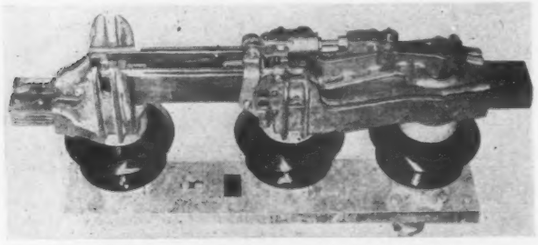

Fig. 13. 4,000-amp., outdoor disconnecting switch.

blades to the open position. The insulator stacks are rotated from shafting carried in babbitted bearings. This shafting is operated from below by means of a 16-in. handle.

To open the switch, there are required fifteen turns of this 16-in. handle at a pressure on the handle not to exceed 23 lb. The grounding switch is operated from below by means of a worm-gear mechanism which requires nine turns of the 12-in. handle to open the switch with the handle pull not exceeding 18 lb. Counterbalancing springs and roller bearings are used on both the 220-kv. disconnecting switch and on the grounding switch. Contacts are of the full-floating type.

Manufacturer "C"

Type TTR disconnecting switch for 220-kv. service has a steel base supporting the insulator columns as shown in Fig. 15, the rotating column being carried on a double Timken roller bearing. Two of these insulator columns are held rigidly in position by a heavy copper bridging member which forms the terminal pad and bearing for the rotating lever.

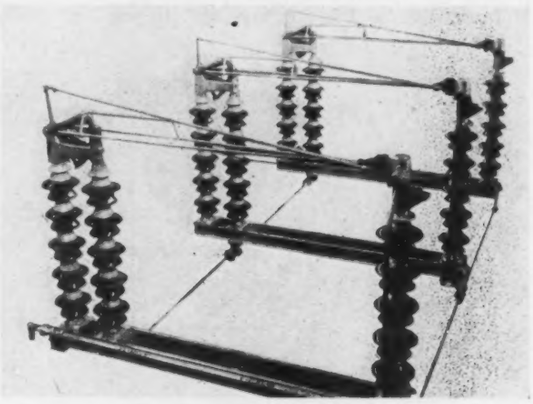

Fig. 14. 220-kv. disconnecting switch.

This ingenious lever mechanism first twists the blade through a 60-deg. turn releasing it from contact with the switch jaws and then lifts it to the open position. All parts of the switch proper are copper and aluminum bronze except the pins which are Monel metal. The switch is operated either by a hand wheel or a motor acting through a vertical shaft and crank gear mechanism. This crank gear mechanism is linked to a bell crank on the shaft of the rotating column by a short tie rod. The three poles of the switch are tied together with two adjustable galvanized iron pipe rods so that one is in tension during closing and the other is in tension during opening.

Fuses*

Manufacturer "A"

A COMBINED fusible cutout and disconnecting switch which is a definite improvement in fuse design and has been developed to meet the demands for a high interrupting fuse is shown in Fig. 16. Positive operation is assured by the introduction of a spring held in compression until the link fuses and which then assists the explosion action in expelling the conducting parts from the tube. This fuse also has the desirable feature of being factory-filled which assures correct fusing and materially eliminates faulty application of fuses by the operator.

To permit the fusing of potential transformers on large systems, current-limiting resistors have been developed which, when used in series with a potential fuse, permit their application to any system regardless of the possible short-circuit current.

The development of a special type of combination fuse and resistor has made possible the tapping of high-tension transmission systems to serve rural sections with small amounts of single-phase power of 10, 15 and 50 kva. at 66 kv. and below.

Manufacturer "B"

Potential transformers play a vital part in modern generating, transforming, and distributing stations in

* Part II of report of switchgear subcommittee of electrical apparatus committee, Engineering Section.

* Part III of report of switchgear subcommittee of electrical apparatus committee, Engineering Section.

that they transform the system voltage to voltages suitable for operating, synchronizing, indicating, and recording instruments. Potential transformers seldom are required to handle more than a 200-volt-ampere load, yet they must be connected to the system at

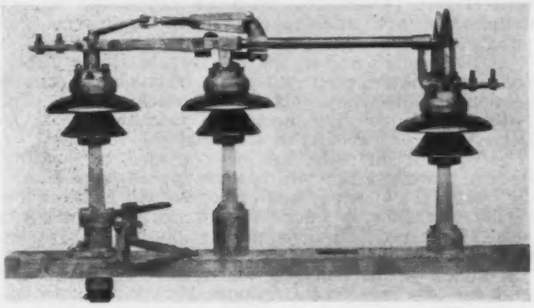

Fig. 15. Disconnecting switch mounting for 37 kv. and 220 kv.

points where their failure will result in releasing the short-circuit capacity of the system. Obviously, current-limiting and indicating equipment should be applied between potential transformers and the primary buses to prevent system interruptions and dam-

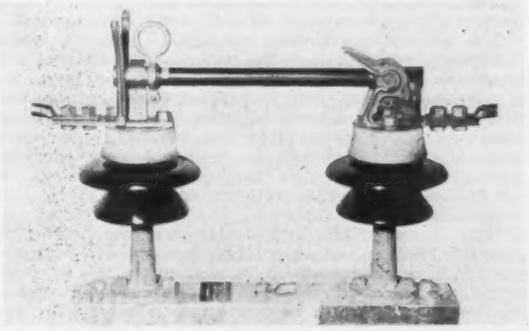

Fig. 16. Combined fuse and disconnecting switch.

age to adjacent apparatus when a potential transformer fails. Current-limiting and interrupting equipment can be applied in such installations very readily and economically and without the power losses which occur in other types of installations. This has been made possible by the development of a special low-current fuse designed for application in conjunction with a suitable wire-wound resistor. See Figs. 17 and 18.

This is a special fuse of the type of construction in which the fuse element supports the extended fuse spring through a system of levers which are arranged so that less than 1/100 of the tension of the extended spring is transmitted to the small fuse element. This fuse is made with current ratings as low as half an 0.5 amp. and will withstand the rush of current which occurs when a potential transformer is energized, yet it will blow when a short-circuit occurs on the secondary of a potential transformer. Thus it is possible to eliminate secondary fuses.

The resistors are of sufficient value to limit the maximum short-circuit current to 150 or 200 amp. regardless of the short-circuit capacity of the system to which they are connected. The resistance characteristic does not change with age or service, and the error introduced by the IR drop of the wire-wound resistor and fuse combination is negligible. The 60-cycle impedance of these resistors is practically the same as the d. c. resistance. When a resistor is

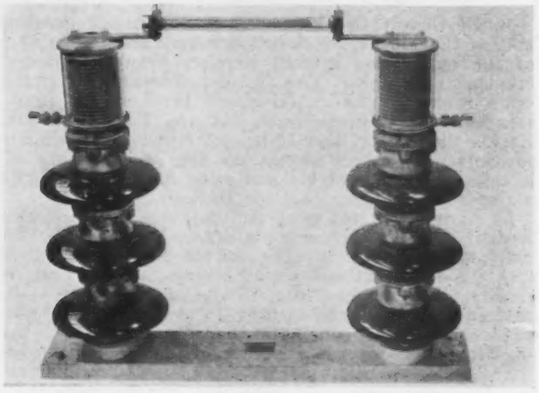

Fig. 17. Combination fuse and resistor.

subjected to steep-wave transients such as occur during arcing grounds and switching or lighting disturbances, the impedance increases due to the increase in reactance. This characteristic provides additional insurance against the possibility of steep-wave transients passing through the resistor and puncturing the end turns of the potential transformer.

These resistors have sufficient thermal capacity to withstand any load or short-circuit current to which the combination of fuse and resistor can be subjected when properly applied. The 0.5-amp. fuse should be applied in standard 2.3-kv. or 33-kv. potential transformer installations, while the 1-amp. fuse should be

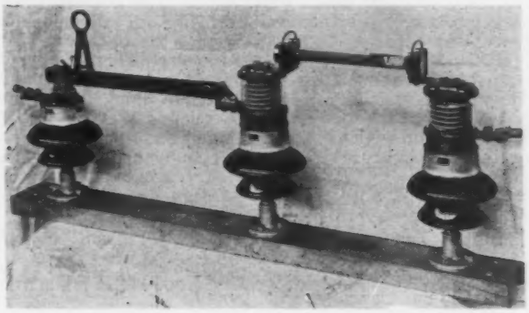

Fig. 18. Combination switch, fuse and resistor.

applied in higher voltage transformer installations because a partial insulation failure can occur in a potential transformer winding which will result in an insufficient flow of current sufficient to blow the primary fuse. This will result in the over-heating and damaging of the resistor. A short-circuited or defective potential transformer is of no use on the system and the quicker it is disconnected from service after its failure, the better. This is accomplished in a minimum of time and with a minimum of disturbance when the 0.5 amp. or the 1-amp. fuses and wire-wound resistors are applied.

Operating Company Reports*

THE following comments have been condensed from the reports of some of the member operating companies.

Los Angeles Gas and Electric Corporation

1. Oil Circuit Breakers.—At Seal Beach generating station the 110-kv. oil circuit breakers are on the floor of the bus rooms without barriers between adjacent breakers or phases. The 13.2-kv. generator oil circuit breaker and the 2.3-kv. oil circuit breakers for auxiliaries are in concrete cells. At the East Side substation the 110-kv. and 16-kv. oil circuit breakers are outdoors. At other substations the breakers are all in cells, some in concrete and some in steel cells with the operating solenoid outside the cell.

At Alameda Street generating station the oil circuit breakers are all in concrete cells. For the FH-203, 206 and 209 switches the bottom slab is built-in with the cell and the top slab is adjusted and grouted in after the cell was cast. Some of the lower slabs are concrete and were cast in the cell, some are precast concrete and some are soapstone. Some of the top slabs are precast concrete and some soapstone. The 2.3-kv. circuit breakers are mostly mechanical remote control operated with bell cranks and rods. The control wiring at Seal Beach station is practically all No. 19-22 color-code cable in paraffin braid. At the substations the wiring indoors is No. 10 rubber-covered and No. 19-22 color-code cable in paraffin braid. Outside wiring is No. 19-22 color-code cable in lead. At Alameda Street station the wiring is all No. 10 rubber covered wire.

All oil circuit breakers on the Los Angeles Gas and Electric system are equipped with disconnecting switches on both sides.

At Seal Beach operation counters are placed on all oil circuit breakers and established routine requires that they be inspected internally and tested mechanically after fifty routine operations, or at least once a year. At the substations and at Alameda Street station they are inspected and tested mechanically every three months. All oil circuit breakers on the system are inspected internally as soon as practicable after opening a short-circuit.

It is also established practice to test the oil when breakers are inspected and to bring all oil up to a 30-kv. test before it is put back into the breakers. At Seal Beach the 110-kv. breakers have separate filing and drain pipes leading from the breakers to the oil room. For all others the oil is handled in buckets or the switch tanks are taken to the oil room. The oil is purified first with a centrifuge and then passed through a paper filter press or, in some cases, with the press alone. At Alameda Street use is made of the filter press only. The substation department uses both centrifuges and filters.

Trouble has occured with the 110-kv. oil circuit breaker bushings getting out of line so that contacts would not "make" properly, both at Seal Beach and at East Side. Considerable trouble has been experienced with loose internal parts in these breakers.

Occasionally the clutch slips on motor-operated switches allowing the motor to run without operating the switch, and switches reclose automatically and freeze after opening on a short-circuit. Difficulty also has been experienced with lever-operated remote-controlled breakers which have heavy laminated contact shoes. These contacts require so much pressure that the operating mechanism "slacks off", reducing contact pressure and causing the contacts to heat.

Oil circuit breakers might be improved by reducing the number of parts and also by increasing the opening speed.

2. Disconnecting Switches.—All disconnecting switches of 30-kv. rating and above are mounted out in the open. All others are mounted in cells except some 2.3-kv. switches which are in the open with transite barriers between phases. The 110-kv. switches have no barriers between phases and all 110-kv. disconnects are mechanically remote controlled. No electrically operated disconnects are employed. Most of the lower voltage disconnects are stick-operated, although some are remote mechanically operated.

At Seal Beach and at the newer substations disconnects are interlocked with the related oil circuit breakers by the Cory-Robinson interlock system. The 110-kv. high-line disconnects are mechanically interlocked with the ground disconnects.

Very little difficulty has been caused by heating. Once in a while a clip will become spread from closing the switch too violently and of course will heat. Some of the mechanically operated switches have failed to close properly on all three phases due to slack in the mechanism caused by wear.

3. Fuses.—Expulsion type and tetrachloride fuses are used on 16- and 30-kv. potential transformers and powder-filled buses on 2.3-kv. potential transformers. Powder-filled and oil-filled fuses are used on auxiliary circuits. No fuses are used on feeder circuits or transformer tanks. Resistors are installed on 16- and 30-kv. potential transformers.

The Southern Sierras Power Company

1. Oil Circuit Breakers.—All recent breaker installations have utilized standard types installed in the usual method, and either hand operated or solenoid operated. Control wiring almost universally is single-conductor rubber-covered wire in rigid iron conduit.

It is general practice to arrange all breakers, large and small, for isolation by means of disconnect and bypass switches. Metering transformers are arranged to permit isolation with the related breaker so that all related equipment can be given a test at the same time. At the time of test the breaker is given a thorough mechanical test to see that it is working properly and that control wiring and switches are in proper condition. Relay settings are tested by sending an overload value of current through the breaker and current transformers and noting whether the relay trips the breaker within correct time setting. Inspection of all breakers under normal operation is made annually and reports kept on standard forms. Operation of breakers has been very satisfactory for the past year.

This company prefers gang-operated, remote hand or electrically operated disconnecting switches and in general all such equipment for 88 kv. and above are so arranged. Circuit breaker disconnects usually are hand operated while bus-selector switches and circuit breaker bypass switches are electrically operated. On 33-kv. switch racks breaker disconnects are stick-operated while breaker bypass switches and bus-selector switches are gang-operated by remote hand control.

2. Disconnecting Switches.—Disconnecting switches on 4-kv. and 2.2-kv. distribution racks are all stick-operated. Indoor low-voltage disconnects for high-capacity breakers generally are gang-operated by remote hand control. Barriers are used only to a limited extent. Complete phase separation is preferred in large capacity installations, otherwise sufficient separation is maintained to make them unnecessary.

3. Fuses.—Fuses are used for transformer bank protection and potential transformer protection. At many of the small 88-kv. and 33-kv. substations transformer banks are protected by fuses on the primary side with circuit breaker protection on the secondary side. Both oil-filled and powder-filled types of fuses are used, the powder-filled type proving the more satisfactory. The use of fuses for transformer protection has proved satisfactory in substations of

* Part IV of report of switchgear subcommittee of electrical apparatus committee, Engineering Section.

smaller capacity where interruptions to service are not of vital importance. The loss of transformers protected by fuses has been very small.

Potential transformers sometimes are fused and sometimes not, depending upon the particular installation. Potential transformers on individual circuits generally are connected in "solid" with secondaries fused at the transformer. Bus potentials usually are fused or connected to the bus through disconnecting switches. Current-limiting resistors always are used on low-voltage large-capacity installations.

San Joaquin Light & Power Corporation

1. Oil Circuit Breakers.—The San Joaquin Light & Power Corporation uses pantograph breakers almost exclusively for 110-kv., 70-kv., and 11-kv. circuits. These breakers all are of the round tank multi-break type and have proved satisfactory to date. Replacement of a number of the square-tank type breakers on the 110-kv. and 70-kv. lines is being made with round-tank breakers due to the greater mechanical strength and higher oil capacity of the latter.

Up to the present time no motor operators are used for circuit breakers, but air is used almost exclusively. A few solenoid operators are installed on 70-kv. switches, but it is believed that air is cheaper considering both installation and maintenance. To date the operation by air has been satisfactory and but little trouble has been experienced with air equipment. A number of unattended "automatic reclosing" stations are equipped with motor-driven reclosing equipment on the 11-kv. circuits.

The later types of pantograph round-tank 110-kv. and 70-kv. breakers are mounted on a concrete base with a steel structure directly over them for dead-ending lines and mounting disconnects. The older types of square-tank breakers were mounted on legs with steel structure overhead. The 11-kv. breakers are mounted on pipe structures with switch hung high enough to allow lowering of the tanks and removal of internal parts of the breakers.

On later installations lead-covered cable with a jute outer covering has been used for protection of control and secondary transformer leads due to difficulties experienced with water entering conduits and with deterioration of conduits. These cables carry marked leads as also is the practice when using conduit.

All oil circuit-breakers are installed so that they may be isolated either by a bypass air switch or a by-passing bus, with disconnecting switches mounted on each side of the breaker. This applies to breakers of all voltages except those in 2-kv. service.

All 110-kv., 70-kv., and 11-kv. breakers are tested each month for mechanical operation. That is, they are caused to be tripped out by the relay circuits by closing the relay contacts by hand. At least once a year each breaker is given an overall test by means of a loading transformer which checks the switch as a whole. This has also been found beneficial in checking poor connections at joints and similar trouble.

Oil in all breakers is tested twice a year and reconditioned if found necessary. It is the practice now to have a storage tank for oil at each station with the necessary piping to each switch and transformer. At the stations not so equipped a portable tank on a trailer or an ordinary 50-gal. drum is used with a filter press to transfer and recondition the oil.

The principle difficulties with modern breakers are with the tripping devices on the breakers which are complicated and difficult to keep in adjustment. Trouble is caused by breakers throwing oil and blowing up, but in the majority of cases this is due to the breaker being worked above its rated capacity. The remedy for the latter is a larger, stronger breaker with more oil, more breaks and greater speed in breaking. It is believed that operating speed of the breaker is a most important item. Actual cases have been found where a slow-acting breaker has failed, but has operated satisfactorily after being adjusted properly.

2. Disconnecting Switches—All of the disconnecting switches employed are stick-operated and very little trouble is experienced with heating. On the high-voltage disconnects it is hard to maintain alignment, but with intelligent operation most of this may be overcome.

Barriers are not used between phases on indoor or outdoor disconnecting switches.

3. Fuses.—All of the high- or low-tension fuses used on the San Joaquin system are of the powder-filled type. Fuses are used on a few power banks up to 500-kva. capacity each and on 11-kv. potentials. These have proved satisfactory and in most cases they clear trouble in good shape.

Great Western Power Company of California

1. Oil Circuit Breakers.—In control wiring to oil circuit breakers it is the policy of this company to run to each breaker a separate conduit containing the closing, tripping, interlocking, and pilot-light circuits. It is company practice to sectionalize the d. c. control buses in order to minimize the possibility of a general interruption due to a local fault in the control wiring.

In main condenser and distribution substations in metropolitan areas use is made of the straight double-bus system in order to render the best possible service. However, in most of the 22-kv. automatic outdoor substations in the rural districts use is made of disconnecting switches to isolate the individual circuit-breakers for inspection and repair, and a bypass disconnect to prevent interruption to the feeder. This feeder is not left without circuit-breaker protection, for a bus-tie breaker is used in conjunction with the main and transfer buses to effect such protection.

2. Disconnecting Switches.—To avoid heating difficulties with disconnecting switches all disconnecting switches are ordered a size or two larger in current rating than the current they are likely to be called upon to carry. Disconnects are selected with bases of sufficient rigidity to maintain alignment of insulators and contacts. No particular trouble is experienced now with hot disconnects on 11-kv. distribution systems or tie lines.

3. Fuses.—For the past thirteen years or more use has been made of oil-immersed fused disconnecting switches on the underground system. These fused switches are installed in manholes to facilitate switching operations. These switches were designed by this company and are made locally.

Pacific Gas and Electric Company

1. Oil Circuit-Breakers.—This company is equipping several indoor stations with 4-kv. switching equipment consisting of oil circuit breakers and related apparatus mounted complete in steel compartments. Appreciable saving is effected in expense and space with this type of breaker arrangement particularly due to the fact that a separate switchboard structure is not required as all instruments and control equipment is mounted on the breaker compartment doors. Interconnecting conduits and wiring between breakers and control switches is reduced to a small amount.

This type of equipment can be purchased complete in unit form simplifying the original installation and readily permitting the addition of future units.

2. Disconnecting Switches.—It was formerly the practice of this company to manufacture disconnecting switches in the company shops, but as it now is possible to purchase suitable equipment this practice has been discontinued, with the exception of 60-kv. and 110-kv. switches. These latter types are built as an integral part of the supporting structures and are gang-operated. The switch bases and arrangement of operating rods and quadrants are such that pur-

chased equipment is not practicable for the company's standard types of switching structures.

In connection with heating difficulties on disconnecting switches it has been found necessary to use considerably larger switches than the name-plate rating where currents in the order of 2,000 amperes or greater are involved. However, recently developed designs of high-current-carrying switches may be an improvement over those available in the past.

3. Fuses.—For many years 60-kv. glass fuses have been used on small power transformers and potential transformers. Troubles with these fuses indicated a weakness in mechanical design especially in the method of mounting. The main difficulty seemed to be due to the fact that owing to the space requirements around each fuse (beneath as well as in other directions) it is not possible, without the use of excessive material, to design a structure with sufficient rigidity between the two mountings to permit with safety, a firm clamping of the fuse tube at both ends. As a result, the fuse tube must act either as a strut between its mountings or else slip at one mounting and at the same time take bending strains. After some study a standard glass fuse has been developed which is fitted with brass ferrules and is loosely fitted to brass fuse holders. Extra-flexible pigtails clamped to the ferrules and connected to the fuse holders furnish the proper electrical connection between fuse and holder. The fuse is filled with Silocel and assorted fuse sizes of from 5 to 100 amp. capacity are used.

On 60-kv. potential transformers tetrachloride fuses with proper resistors now are being employed.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

HYDRAULIC POWER COMMITTEE REPORTS[2]

Hydraulic Plant Operating Problems*

In past years, the major part of the work of the hydraulic power committee has been confined to the problems of design, manufacture and construction. Too little time and effort have been devoted to the problems of operation. Therefore this subcommittee was appointed to go into the matter of hydraulic plant operating problems in a systematic and thorough manner.

The purpose of this report is to bring to the attention of power plant designers, builders and operators the problems involved in hydraulic plant operation as discovered by engineers, superintendents and foremen in charge of plants, and to formulate recommendations for improvements in design, manufacture and construction to help prevent the occurrence of operating troubles. It is divided into eight classifications, including storage reservoirs, water conduits, penstocks, forebays and surge tanks, hydro-plant equipment of the impulse-wheel type, hydro-plant equipment of the turbine type, hydro-plant equipment, and partial and full-automatic auxiliary power house equipment.

IN RESPONSE to the questionnaire considerable data were gathered by each of the committee members, a portion of which pertained to methods rather than problems. Although valuable and very interesting, information on methods has been omitted in order to condense the report as much as possible.

Storage Reservoirs

Hand wheel and steep pitch threaded shaft, for the operation of slide gates, work easier than a geared lever control.

It has been found that the limitation in size of the conventional hand operated slide gate has made it necessary to use a number of these gates to pass sufficient water for any development of reasonable size. This multiplicity of gates and the time required for their operation has greatly reduced their value as a means of stopping the flow of water in emergencies. Effort is being made to convert this type of gate control from hand to power operation, preferably by the use of oil-pressure actuated pistons directly connected to the gate stem. Periodic testing and inspection has been found necessary to keep this class of equipment in good operating condition.

It has been found that where a butterfly valve is used with a free discharge the motor supply for operating same is generally too small. Considerable trouble has been experienced with foreign material catching in control gates. The grizzlies used were made so that material of any size could not enter crosswise, but we find that a 2 x 4 if turned just right can go in lengthwise, and have recently had to cut such a stick out of a Johnson valve.

It is a serious problem preventing moisture from shorting and grounding control and lighting wires especially where lighting circuits are at different elevations in the shaft and inspection tunnel.

If gates are motor controlled, separate lead-covered circuit through conduit and without splices should be provided. Lighting circuits should be separate and Marine fittings used. Conduit should be so installed that any moisture that might collect in same will drain out. Fixtures installed on conduit in roof of tunnel should be placed above elevation of conduit, to prevent drainage into the fixture.

Logs and other floating material gathering on the surface of a storage reservoir constitute a serious disposal problem. The opinion in the reports on this subject is that the most economical way of disposing of logs and trash is through the spillway. During the high water period this is generally accomplished by using two log booms as wings; then by employing a third boom with a man in a boat at each end, the logs can be gathered and forced out through the opening in the spillway. This method would be facilitated if

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* Report of subcommittee of hydraulic power committee, Engineering Section. L. G. Roberts, chairman. E. A. Crellin, R. S. Daniels, C. L. Davis, J. A. Koontz, Jr., R. B. Lawton, E. A. Quinn, R. R. Robertson, H. C. Stanley, P. J. Ost.

the middle section of the spillway were made a few feet deeper than the rest of the spillway.

Lake gaging is one of the major problems of the lake tender especially if the lake is used for regulating in which case one or two readings a day are required. These readings must be fairly accurate as the dispatcher distributes his load accordingly. In most instances a staff gage is used mounted on the face of the dam; if mounted elsewhere the snow and ice break it down. During the winter months when the water is low in the lake, the gage cannot be read from the dam, and it becomes necessary to get out on an adjacent point and use field glasses. During the heaviest storms this is hazardous; moreover the view is obstructed and the result is guess work. Remote indicating gages would be ideal for this purpose if it were possible to secure the range; in many instances this is between zero and 200 or more feet. Pressure gages are unsuitable as a change in load changes a pressure reading.

Considerable difficulty has been experienced with remote indicating water level gages where the apparatus functions through the agency of contacts, ratchets, or complicated mechanical devices. Rapid fluctuations in water level even though damped out by stilling wells, will eventually cause errors in indication that will discount their reliability. A suitable float well is necessary and we would suggest that when a dam is constructed two pipe wells be installed, the entire height and connected at the bottom. The float well should be 10 in. in diameter and the weight well 2 in. to 3 in. in diameter, and both wells should be located back one or two feet from the face of the dam. With this arrangement the modern distant water level indicator of several types could be installed and the surface of the water in the wells could be kept from freezing by the addition of a small amount of oil.

One problem in connection with the measurements of spillways is the necessity for periodic readings taken during each 24-hour period. This can be eliminated by installing a suitable water-level recorder which gives the height of water behind the spillway at all times. On the chart a record of all gate or flash board changes should be kept.

A float chamber should be so constructed that oil can be used to prevent freezing. Considering the first cost of spillway gates, flash boards are perhaps the cheapest construction, but they have many disadvantages. Considerable leakage occurs that is hard to prevent. Replacing or removing boards is very inconvenient and extra hazardous. Replacements are quite frequent and boards have to be sized.

One trouble experienced with remote controlled, motor-operated radial gates has been the breaking of the lifting chains. This was overcome by closer adjustments in order to get equal tension, and by setting the release of the motor so that the chains are still taut when the lowering mechanism comes to rest. If this is not done and the chains are allowed to become slack, it invariably follows that only one chain will be taut during the raising cycle until it clears the curvature of the gate when, due to fouling or twisting, the slack may be enough to break the chain when the jar comes.

Another trouble experienced was the gate not "staying put" or "crawling" when raised to a partly open position. The weight of the gate starts it to creep, putting the back gearing into motion, finally coasting down to closed position. Mechanical brakes have been tried on the hoists but required constant adjustment to overcome wear. Magnetic brakes have since been installed, which are satisfactory. It is suggested that equipment of this kind be designed and furnished with magnetic brakes, braking on the motor shaft. This would also aid in maintaining adjustment on the chains, for without brakes, a taut chain in cold weather may mean a loose one in hot weather, due to oil and grease solidity. Counter balancing the gate has been suggested. Worm gears may be used on gates operated by individual mechanisms to prevent slipping.

Another trouble experienced with the control of gates was caused when only one source of power was available for the gate control circuit. With trouble at the source of supply there was no immediate way available to spill water to supply the downstream plant. Too delicate a setting of the contact mechanism on the gate control may result in the gate starting to raise, merely due to a sharp jar on the outside of the motor housing. The housing being locked, the gate cannot be stopped or closed until the operator's attention is called to the condition. Proper adjustment of the contact mechanism is very essential. Where large amounts of water must be spilled in a short time it is advisable to have individual gate control, as much time is lost transferring a hoist from one gate to another, where several gates are handled by one hoist. Every effort should be made to make their control convenient and fast enough to take advantage of the facilities offered by their use. A knowledge of the characteristics of each gate has been found very useful in handling such emergencies as have arisen.

Leakage of dams requites very close attention and it has been found advisable to take daily readings at important points and keep on the alert to note any changes in quantity or color of the leakage; control of leakage varies with the different formations and surfaces. Where leakage is anticipated suitable drain tile should be provided to make such leakage plainly visible.

All drain pipes located in a dam especially for the purpose of draining gate chambers and galleries should be installed of ample size, and should be run straight to facilitate cleaning, which has to be done quite frequently on account of some chemical action which causes the drain pipes to corrode.

All spillways should be provided with suitable catch basins so arranged that the energy of the spill water is imparted to water that would normally be at rest. This method has proved to be very satisfactory and has resulted in a low maintenance cost.

Considerable trouble has been experienced with undercutting of conduits at reservoir inlets at times of low water level. This has been minimized to a large extent by providing a sloping apron that carries the water from the conduit to the minimum reservoir level, and there imparts its velocity to water normally at rest. This eliminates the severe impact that results when the conduit discharges its water against the bottom of the reservoir or other immobile objects.

Water Conduits

The present method of measuring water in open conduit may be accurate but it would be hard to convince the average practical man, especially when he sees different engineers get different readings for quite apparently the same amount of water.

Calibrated sections, free from bends and other disturbing factors are provided at important points. These are utilized for tests on new equipment, adjustment of other measuring devices and such special tests as may be needed.

One company contemplates installing a Venturi flume for trial and it is believed it will prove satisfactory. The measuring method commonly used, consisting of the staff gage and bottle float is very inaccurate. It may have answered the purpose in the past, but due to the scarcity of water and the large expense of impounding it, special effort should be made to provide a more accurate method. The advent of the irrigation districts is a further reason for more reliable methods of measurement.

Considerable difficulty from loss of water in canals has been experienced, in most cases due to the general formation and soil conditions of the country through which these canals pass. One important problem is the damage to adjacent farming and orchard land which subjects the operating company to heavy damage suits and affects public relations. This problem is gradually being overcome by guniting the leaky sections. One

cause of canal leakage is the method of building up the berm. When the canal is excavated, large rocks, small rocks and soil are dumped wherever they will stick, resulting in a berm full of voids, whereas a little careful segregating and placing in the first place would give a tight berm. Sometimes it seems that enormous sums are expended building a water-tight dam to conserve water and then a canal is built away from it with the leakage several per cent per mile thus creating an everlasting problem to the operating man. Ground water exerting pressure on side slabs of concrete lined canals displaces them. This condition may be remedied by drilling holes, thus relieving pressure.

Anchor ice, floating snow and ice, freezing gates and measuring gage wells are some of the problems, due to low temperature. Ice breaking up and floating against intake racks tends to shut off water. Some trouble has been experienced with frazil ice during a relatively short period. Taking care of this condition has necessitated by-passing a large amount of the water carrying ice over the spillway, and at the same time dropping load to a considerable extent. Increasing the amount of water in the canal improves the anchor ice condition.

Another remedy is to bring spring water into the canal whenever possible; this being much warmer it melts the ice and snow. Floating snow trouble is not generally caused by the snow falling directly into the canal, unless there is no water in the canal at the time and the snow is allowed to accumulate. Generally the trouble is caused by the large amounts of snow that accumulate on the berms and slide into the canal long sections at a time. This might be overcome to some extent if the slope of berm were such that it would hold the snow. Exposed pipe and fittings not influenced by the circulation of water should be protected from freezing in cold weather.

Quite often in a conduit consisting of open ditch and a few tunnels, the tunnels are the limiting sections. This may not have been the condition when first constructed but a few years later it may be discovered that in cleaning the open ditch the berm has been built up, thus giving greater capacity in the ditch section, but leaving the capacity of tunnels unchanged.

Tunnels operated under constant head as a rule give little trouble, but those subject to varying heads do not have such a good record. One trouble observed on those of the latter class was that the linings showed signs of distress at points where the variations of the head were the greatest. It was decided that this was caused by external pressure on the lining, resulting from accumulations of water that had worked out through small openings, over a long period of time when the head was high. The external pressure comes into play as soon as the head on tunnel is reduced. Weep holes of sufficient capacity drilled through the tunnel linings at suitable locations to permit a circulation of water back and forth, and thus prevent any undue pressure on the linings, seem to be the best solution.

Swelling ground has caused trouble at several locations and has been combated by strengthening existing walls with auxiliary steel work bolted in place inside of the tunnel. This reduces the carrying capacity slightly but it is only considered a temporary measure intended to keep the tunnel in service until other work justifies the shut-down necessary for more permanent repairs. Trapped air has been thought responsible for surging and reduced capacity observed when a partially filled tunnel carrying a given quantity of water is called upon to carry a larger quantity at a head sufficient to completely fill it. Longitudinal vent pipes connected to suitable outlets have been considered as a remedy, but the absence of definite data has delayed their application.

Decrease of capacity has been experienced due to a biological growth of some sort which occurs in the summer months. One successful way of handling such conditions is to shut the water off for a day or so which allows the growth to dry up and slough off. At certain seasons it will reoccur in six weeks and require the same treatment. This condition does not exist so much in our mountain system as it does further down in our irrigation ditches where the water is warmer. The irrigation ditches have to be cleaned at least once each year.

A peculiar case was that which occurred in 11,000 ft. of redwood flume running north and south, in which moss formed on the east side and bottom of the flume. A water level recorder located at the end of this flume served as a means of detecting the trouble. Upon investigation it was found that moss had accumulated to the extent of some 2 in. on the east side of the flume and probably ½ in. to 1 in. on the bottom, and ¼ in. to ½ in. on the west side. To remedy the condition it was necessary to unwater the flume and entirely remove the moss.

Some trouble has been experienced due to reduced capacity in steel pipes caused by biological growths. This has been more pronounced on the plates than on their fittings, with cast steel showing the greatest resistance to their attack. About the only remedy is to clean and repaint the pipe when conditions are bad enough to justify the expense. It is believed that higher velocities than those now commonly used would produce sufficient scouring action to hold these growths in check, without causing noticeable loss in efficiency. Bluestone suspended in a sack in the ditch clears the Algae but is not used on account of the effect it might have on domestic water.

Considerable difficulty is experienced from scouring, erosion and rusting of metal flumes. A request for information on erosion of metal flumes brought the following answer:

"There are two classes of conduits; those carrying water up to, say 6 ft. per sec., and those carrying water at higher velocity. It has been our experience that for velocities of under 6 ft. per second any good grade of paint such as used by the U.S. Bureau of Reclamation, consisting of a priming coat of water gas tar covered by a coat of coal gas tar, applied hot, or a good grade of asphalt paint, will protect the flume for considerable periods of time."

Proper drainage will prevent many slides but quite often the width of right of way is not sufficient to provide proper drainage. Frequently slides are due to the natural formation of the ground. This condition is obvious when the canal is dug and if measures were taken at that time for correction the cost would be much less than at a later period. Several companies reported trouble from horses, cattle and deer falling into the canal. This trouble has been overcome to some extent by flattening out the berm in the worst section and building it in step formation out of concrete blocks, which allows the animal to climb out. One company reports it was necessary to fence the entire length of the canal. One great nuisance is caused by hogs along our small irrigation canals.

Forebays and Surge Tanks

By using enameled numbers on gage boards and selecting the proper place for the gage, most gage troubles have been pretty well taken care of. Distant water level recorders are being used to supplement or replace gage boards. There is one especially good recorder on the market which is used extensively and which by the addition of the gear train from a watt-hour meter will read to one hundredth part of an inch. One recorder of this type has been used on a forebay where the water elevation can vary 32 ft. The instruments are delicate and have to be protected by fuses and lightning arrestors. The current is small and the buses are light and some trouble has been experienced in making a fuse of sufficient mechanical strength; this was overcome by inserting the fuse wire between two strips of mica. One reported difficulty with distant water level indicators was due to the fact that chain and water level range from zero to 60 feet at the lower

levels. This left a considerable strip exposed to the wind which made the readings rather inaccurate. These recorders should be a dependable no voltage alarm, and the float should be so installed that there is no danger of sticking or becoming jammed.

One company reports that they had an installation which paralleled an 11-kv. transmission line for approximately six miles and so much trouble was experienced that the use of the device was finally abandoned. Another company had a similar experience but overcame it by transposing the signal circuit. Another company reports that considerable trouble has been experienced with distant water level recorders of several different makes aside from the circuits themselves, that is they have been subject to inaccuracies due to inherent causes or power interruptions. Some have good features and some have features not so good, and on the whole there would seem to be room for improvement.

Trouble with trash or grizzlies has been ovecome by removing the small surface grizzlies and installing screen tower grizzlies. One company makes it a practice to lower the water and clean these grizzlies twice a year. Where ice and snow accumulate, platforms and railings should be eliminated from the box grizzlies, as the weight of the ice and snow breaks them down, and they also form a catch-all for the trash.

One company reports considerable success with using a self cleaning rack in a canal a short distance above the forebay. This keeps the trash etc. out of the forebay and consequently off the penstock grizzly.

Control of weeds and other growths is an operating problem that arises each year and if not taken care of the rip-rap will be forced out of place and gradually destroyed. The removal of weeds each year tends to loosen the rip-rap. The work is an operating charge, and could be avoided if the rip-rap were plastered or gunited when installed. Some trouble is experienced with water grass in the forebays. As it is impossoble to drain the forebays in order to kill the grass it grows to maturity and detaches from the roots and drifts onto the screens where it has to be raked off and burned.

Due to the fact that the water in the canals is used for domestic purposes, more or less, and also that the cattle have access to the berm of the ditches and to borders of the reservoirs, remedial measures of a poisonous nature must be avoided.

Silting is a problem which has not been satisfactorily worked out. Sandboxes and traps have been designed which in some cases have been fairly satisfactory. Silting of forebays constitutes an economic problem. Quite a number of plants could be shut down for eight hours out of the 24, if the necessary forebay capacity were provided to store the water. The advent of automatic and semi-automatic plants has increased the necessity for more ample forebay capacity.

The majority of companies report silting as a problem for which they have found no remedy, with the exception of periodic shutdowns, at which time the silt is removed. Hydraulicking, sluicing, line drag and scraping methods are used, but it seems that sluicing is the cheapest method providing the drain pipe is of ample size and properly located.

Penstocks

It seems to be a general practice among the different companies for emergency closings of the headgates. The opening operation is performed at the gate as the penstock should be filled slowly. The control circuit should not be too close to the penstock as a bad break might put the circuit out of order. It is necessary that periodic inspection and operation of the apparatus be made so as to reduce, as far as possible, failure to operate when the emergency arises. One company reports all main penstock valves are power operated by either oil or water pressure.

Forebay valves are arranged for remote closing only through the agency of electrically operated control valves. This scheme has not given any trouble except that it must be used with extreme care. Control switches for emergency closings are made simple and positive. They are so arranged that it takes several consecutive moves correctly performed to secure an operation. Control circuits when not in use are so connected that crosses with other circuits or surges caused by lightning will not cause undesired operation.

Sectionalizing valves are power operated with straight manual control. This insures proper supervision when filling or draining lines. Where valves are operated by gravity pressure from a storage tank, it has been found necessary to rearrange the piping, so that positive pressure from the pump used in filling the tank can be made available in case of sticking of the main valve. This involves a study of the strength of the component parts of the valve, and an adjustment of the relief valve on the pump, so that excessive strains will be avoided.

Selective dial switches at gates are sometimes used to pick out the proper gate. Where power and control lines are kept energized, trouble has been experienced in consequence of damage to cable from outside causes, which resulted in shorting control wires and putting the gates in operation. The same has happened through shorting of overhead conductors. PG 6 relays are connected in ammeter circuit of power lines, to give alarm and cut off power at circuit breaker should control lines short or gate start to close from any cause. When it is desired to operate gates the relay is made non-operative.

Provision is made for emergency closing, automatically, in case of penstock break. This is by means of a Venturi tube which is arranged to operate the closing switch on the gate should the flow of water, through the penstock, exceed a certain quantity. A continuous check should be made of the fuses protecting the motors. It is so arranged that a blown fuse puts out signal lamp and operates a buzzer.

In repacking slip joints very little trouble has been experienced, where the pipe has been plated with copper, but where rust accumulates the packing is destroyed much more rapidly. One problem in repacking slip joints is to get the packing to enter, particularly on the upper end of the penstock, where the pipe metal is thin. The pipe takes an elliptical shape and at some points there is ample space while at others practically none at all. This might be overcome by making the joints of heavier metal.

Another problem is the manhole covers. These are hard enough to enter under the most favorable conditions, but when they are located on top of the penstocks, and stick out catching ones clothes, it makes one wonder why they are not installed in the lower quarter of the pipe by means of bolts and a flange.

For camp and power house supplies at a high-head plant, a tap from the penstock, needle valve, float arrangement, diffusers and tank has been used. There are several objections to this system. It is necessary to use water that could generate kilowatts and there is more or less danger in that part of the system between the tank and the penstock. The pipes and valves are liable to freeze and be broken off, which involves draining the penstock to make repairs. The diffuser is continually wearing out and the float arrangement demands considerable attention.

When pressure reducing valves are used for extremely high pressure the diaphragm wears out readily. Float valves on supply lines acting as a reducing medium give considerable trouble due to surging. One economical method used is to pump into a tank system from the afterbay.

Air valves should be housed properly to prevent snow, rain and water from accumulating on top of them and freezing. Each valve should be separately housed and the housing filled with sawdust; the upper valve chamber should be tapped as near the bottom as possible for ½ in. pipe. After the penstock is filled the gate valve under the air valve should be closed, the water drained out through the ½ in. pipe, and the upper chamber

filled with waste oil; the gate valve should then be opened. With this arrangement the air valve will not freeze.

A small hole should be bored in the end of the valve stem to allow a rod to be inserted to twist the valve around when it leaks; this eliminates the use of a wrench which might damage the valve stem.

On a wood stave pipe installation, using wooden cradles, some cradles were set on longitudinal mud sills resting on a prepared fill. Subsequent settlement, particularly near the edge of the fill, has caused the bottom of the cradle to bow, following the shape of the fill settlement, and resulting in spreading the cradle parts and flattening of the pipe. It is difficult to correct a condition like this, except by complete cradle replacement. Where construction of this type is necessary, ample drainage should be afforded. The top width of the fill should provide wide shoulders and the fill should be thoroughly compacted. Best results are obtained by use of concrete footings having sufficient bearing area to resist settlement.

Some trouble has been experienced from the back fill leaving the pipe on account of the action of same. This was remedied by refilling and tamping. A better way was found by filling the opening with dry sand, since this did not disturb the original fill and made a tight job.

Considerable difficulty is experienced with wood stave pipes which are a part of a penstock that is subject to heavy line disturbances. In two installations of 8-ft. inside diameter pipes in a cut for a distance of two-thirds of their length, considerable trouble is experienced after every heavy disturbance and it takes from three days to a week to stop the leaks. The pipes assume an elliptical shape and leak at the center seam on each side. These leaks are hard to catch up and besides they wash the bank of the cut and accumulate material under the pipe which has to be shoveled out. When necessary to govern with these stations the wood stave pipes breathe and leak.

It is recommended that a wood stave penstock is not suitable for a governing station or a station that is subject to heavy disturbances, and the wood stave pipe should not be laid in a cut.

In many instances a portion of the penstock should be protected from rolling rocks by erecting a fence similar to that used by the highway engineers. In some instances it is necessary to build a concrete deflecting wall.

For water measurements, Venturi meters are in general use and as there is very little movement of water in Venturi meters piping, this water will, if exposed to low temperatures, freeze. Experiments have been made with cork lagging. Piping thus protected would freeze at low temperatures. The cork was then removed, the pipes wrapped with burlap, cork replaced and burlap wrapped over the cork. There has been no further freezing, when this method has been followed.

As a small pipe freezes much more rapidly than a large pipe, the piping to a Venturi meter should not be made too small. Any insulation used on the pipe should be protected from the rain. Venturi meters are read at approximately the same time of the day each week, and checked against the kilowatt-hour output of the plant showing the kilowatts per sec.-ft. generated. Thus any discrepancy in the instrument is quickly detected and accounted for.

Hydro Plant Equipment of the Impulse Type, Attendant in Charge

High-pressure gates in power houses of older construction, have given considerable trouble with the wedge-type gates, both solid and two piece plugs. In some cases it has been necessary to replace the gates with the single straight-faced, seat type. In other cases it is still necessary to drain pipe lines and allow the wedge-type gate to be closed in case of failure of needles to close for any reason. In some cases in up-to-date plants, companies are still using the wedge-type gate valves. It is suggested that all high-pressure gate valves be of straight-faced, plugged design, whether double or single opposed.

Main valves of the internal plunger type have been found very satisfatory after a suitable form of control was developed. The early type of control was not positive and could cause serious water hammer under certain conditions.

A form of control was adopted that used the motion of the value plunger to vary its control in such a way that it is independent of the water flowing in the main pipe line, requiring as it does a complete follow through operation of the control valve. A motor mechanism with several push-button stations is arranged to operate this control in a time commensurate with the characteristics of the penstock.

Where a gate is feeding an open-type nozzle, erosion of the valve seat disk and gate body is a problem not easily overcome. The gate body can be designed to some advantage with additional metal at point where erosion takes place. Disk and valve seats are subject to immediate wear horizontally at about central position; in other words when disk has started to open there is no bearing behind it on lower portion and the bearing surface, in design of most gates, gradually decreases until disk has reached half open position. During this movement of disk the discharge of water is of course increased as gate is opened, and the disk has a tendency to tip over and blow out through the opening. This places considerably more pressure on lower edge of disk where there is the least bearing surface, and wear on both disk and seat continue at point mentioned.

Gate-valve stem packing is a source of considerable expense and trouble if not properly designed. Bronze stems are most generally used and where there is such a terrific strain on the threads when opening and closing or if valve over-travels, the bronze threads will assuredly be strained, often changing the thread pitch enough to cause nut to bind. Valve stems and packing trouble have been overcome by making valve stems of marine steel.

Where the packing surface came in contact with the stem it was turned 3/32 in. diameter undersize and the rest of the stem was left rough. The undercut section was filled in with tobin bronze with an acetylene torch. The stem was then straightened and finished all over, installed, placed in service in 1924 and no further trouble has been experienced.

Several butterfly valves that do not have an adjustable seat were reported, and the leakage is considerable. In some cases the condition is so serious that replacing the values is being considered. The leakage is more pronounced at the axis and would indicate that when installed they would take an elliptical shape when the concrete was poured around them.

Some trouble has been experienced with the bypass valves around the butterflies, and quite often it is necessary to bypass a small amount of water for a considerable period when the plant is closed down. Rather than cut the butterfly the bypass is used. Some of the bypass valves are not constructed for this purpose and the continual vibration destroys them. Sometimes we find a valve in which the packing around the valve stem cannot be changed unless the penstock is drained. If possible the bypass valve should be so installed that it does not create a tripping hazard. Grease cups should be substituted with alemite fittings.

No trouble is reported with the control of high head gates with the exception that where penstock pressure is used it sometimes becomes necessary to operate the gate, when the penstock is empty. Ball-joint difficulties are generally confined to the gaskets and trunnion pins. Carefully selected leather is necessary. In recent years it has been a problem to secure leather of an equal thickness and texture. In most instances the leather provided is treated in some manner, which makes it difficult to form the gasket. The use of non-oiled leather and saturating it thoroughly after pressing

with neatsfoot oil, makes the gasket very pliable; covering the surface of the gasket with a coating of grease and powdered graphite is also effective. The life of the gasket so treated has been increased 100 per cent over non-treated gaskets.

Small rocks, grit and sand are the cause of treated gaskets giving trouble, but being pliable, they are not so subject to cutting as the harder gasket. When the gasket starts to leak other than sweat, it should be replaced immediately or cutting of the ball itself will take place. If operating conditions will not permit taking unit out of service and ball becomes damaged, fine slots can be filed out if care is taken to give a large radius.

Trunnion pins give some trouble in cutting due to lack of lubrication. The very short movement under such a tremendous pressure does not allow lubrication to get in between bushing and pin, but if properly oil grooved and liberally lubricated with a light lubricant the difficulty can be overcome. The elimination of ball joints is advocated, and the use of rigid type construction is favored. Maintenance work on ball joints would be expedited if the concrete were not poured so high under the joints.

Needle tip and nozzle problems are confined principally to wear due to sand and grit in the water. As it seems impossible to remove the cause, attention has been turned towards improving the tips and rings against erosion. Much has been accomplished along this line, by welding a layer of stellite on where the wearing around occurs, and then grinding it down to a fit.

Needle and nozzle leakage in some instances can be overcome by drainage of the nozzle body, disconnecting control mechanism and grinding the tip of the nozzle seat as in an auto valve seat.

In cases where the grit is excessive and wear is beyond the valve grinding process the needles are removed, put in a lathe and the seat portion only is dressed up true, the balance of tip surface is untouched or dressed with a mill file while in the lathe. This eliminates the frequent changing of the needle and nozzle tip as a unit. It is suggested that future design in needle nozzle construction be so arranged as to allow for handling of the needle more readily for a valve grinding or seat grinding operation.

Some trouble from nozzle studs crystallizing and the nuts working loose has been reported. With a modern type needle, the accumulation of silt in the nozzle mechanism will eventually prevent the needle from closing; this condition has been remedied to some extent, by tapping the pocket and installing a valve, whereby it can be flushed out frequently.

Hydraulic-jack problems are confined chiefly to erosion caused by grit and freezing. Freezing difficulty was overcome, in one case, by allowing the waste water from the transformers to pour over the jacks. The lack of lubrication according to the reports submitted is one of the chief causes of our operating problems. On the most modern equipment, recently installed, improvement in the lubrication system can be readily made.

Apparatus located below the floor line is subjected to all the dust, grit and foreign matter that is sucked into the wheel pits and quite a bit of this gets into the moving parts. It is recommended that all joints and bearing be protected and greasing arrangements brought through flexible pipe or otherwise to a point above the floor line where grease can be applied conveniently. Grease cups are being supplanted by alemite fittings and the grease applied by portable hand operated guns. Standard connections and suitable shut off valves are required. It is necessary to renew all belting for governor drives about once a year and to use all possible care in its application and maintenance. Practically all governors now used have manually operated load limit devices and these are so used that the maximum gate opening is under constant supervision of the attendant right at the machine. Belt breaking devices have been dispensed with as they were a serious source of trouble. It is understood that a machine being started is under the constant care of the machine attendant until it is on the system and in the hands of the switchboard operator. In this way there is little likelihood that anything more than a slight increase in speed or load could result from a broken belt.

In some types of governors cast gears are used rather than cut gears. The roughness of the cast gears is a source of trouble causing the pilot valve to continually operate and the speedometer to fluctuate. Where direct drive is used to operate, in a recent installation the governor spiral gears are used, the ring gear on the turbine shaft is made of steel and the pinion gear of bronze. After six months operation the bronze pinion was practically worn out.

Another trouble reported was due to the vibration of the drive shaft. This shaft is inclosed in a metal tube and it was found that if the vibration were allowed to continue the tube would become so hot that one's hand could not be pressed on it. This was overcome by using additional support and bearings. Another source of trouble is the make of lubrication for the moving parts.

On the late governors oil pressure of 200 lb. per sq. in. is used. This necessitates specially constructed receivers; each year state inspectors examine these tanks and the original allowable pressure is decreased. Unless a considerable safety factor is allowed in the beginning, it is only a short time until the receivers can not be used. We find that better operating conditions exist where the oil level and pressure are separately controlled.

One company reports that most of their water wheel troubles are confined to the buckets. Cracks and pits as they develop are welded by acetylene or electrically; loose studs develop occasionally and have to be replaced. Periodic inspection at least once a week is necessary. A recent bucket installation indicates a much better bucket mechanically than those installed in the past.

One company reported that nearly all the buckets for eight units, purchased in 1912, have developed cracks apparently from internal stress, but after being properly welded no further trouble was experienced.

Tail races of the basin type with adjustable discharge so that the minimum water level can be made sufficiently high to prevent cutting action by the water discharged from the wheels, give the least trouble. Considerable trouble has been experienced by one company in getting the wheel pits water tight. The pits are provided with an inspection and air intake pit. These leak very badly and it was necessary to line them with steel plates welded together. The space behind the plate was filled with cement grout. Even this was not entirely satisfactory and at the present time, one of these linings is being removed with a view to putting in a new one more completely welded to the plate lining in the main pit. Some trouble has been experienced with water going through the small space between the nozzle tip and the pit lining material. The plates will be welded to the tip body. The pit lining plates are three-eighths of an inch in thickness and are attached to walls with split bolts, the space between the plate and the wall being filled with grout. It seems very difficult to keep these plates tight. Some trouble has been also experienced with the keeping of the vortex baffles tight.

Bearing troubles resulted in excessive heating and even burnt out or badly wiped babbitt surfaces due to water jackets clogged by mud. Two cases were reported in which the water jackets were faultily designed, the four compartments in water jackets being connected in multiple, where they should have been in series. The circulation was nil, making a settling basin out of the water jacket and leaving a small passageway directly across one end of the bearing only.

In all these troubles, correction was made by suitable filters and properly circulating water through water jackets. The use of filters or settling tanks as the

case may warrant, is recommended to secure a supply of clear water at all times.

The lighter grades of oil now used require better gasketing of joints at bearings, and frequently felt wipers at the shaft. The large factor of safety in this type of bearing and its accessibility make it very popular.

It has been found necessary in most instances to insulate one of the bearing pedestals from ground, in order to prevent shaft current and deterioration of the babbitt metal. It is recommended that the hand covers on bearing next to collector rings be made of insulating material, to prevent short-circuiting of collector rings if cover is accidentally dropped on same. It is also recommended that more attention be given in design, to prevent oil throwing and creeping.

In all the papers received on hydraulic problems, no trouble with air cooling equipment was reported.

Hydro-Plant Equipment, Turbine Type, Attendant in Charge

Pressure regulators on this type of machine are analogous to safety valves on steam boilers, and should receive as much attention. Practically all regulators have given trouble through excessive wear and vibration. Relief in this matter is largely up to the designers, as the mountings are such that it is very costly to make any changes after they are installed. It has been the practice to operate these regulators as semi-synchronous bypasses, with manual adjustment to prevent water wastage. This increased the safety factor on the hydraulic equipment and is conducive to the close attention so vital to this class of equipment.

Pressure regulators sometimes stick owing to small parts in the regulating valves becoming clogged with sand, leaves, etc., which necessitates close attention to the filtering of the water supply for that purpose. A center deflector and steady bearing support in a double runner center discharge turbine was lost, due to loose bolts, resulting in the deflector snapping off, probably due to vibration. Replacement of part was necessary.

Pressure regulators of the auxiliary needle type used in some of the high head impulse units have not caused any operating problems except the frequent change of the needle tip and throat ring. It is probable that the use of stellite or some other very hard material would reduce this maintenance charge.

In two high-head plants using impulse wheels and where water pressure, lower than penstock pressure, is used to hold the valves normally closed some problem has arisen in connection with the auxiliary equipment. Such equipment should be installed with due regard to its importance. Piping should be of ample size and strength and laid so that danger from slides, etc., are at a minimum. Protection from frost should be provided where necessary.

Regulators of this type require very careful upkeep. The needle control mechanism to the differential pressure chamber must be in good adjustment and tight. If this is not done the valves may drop open or not close properly after operation. Energy absorbers are better left loose than tightly bolted in place.

Pressure regulator problems sift themselves down to some four causes. First design and accessibility of the wearing and adjustment parts. Second, mud and foreign matter in the supply water to control valves etc., or the lack of attendants to properly clean strainers or filters or to lubricate the points of friction bearings etc. Third, due to cases of variable head such as where regulators discharge from storage reservoirs at high and low water period. Fourth, lack of knowledge or failure of attendant to adjust needle valve, which supplies the control valves and piston.

Thrust bearings have been giving fairly good service but improvements are still in order. It has been found that shaft currents are very destructive to this type of bearing and special attention to the insulation of bearing brackets, piping etc. should be given. Regular tests should be made on this insulation to see that it is in good shape. The use of inferior oil bearings of this type has been found to result in excessive foaming and finally a complete loss of lubricating value.

It was suspected that harmonic vibrations might be caused by the symmetrical arrangement of slots in both the stationary and running plates and tests have been made with plates having a non-symmetrical arrangement. At present bearings having a different number of slots in the running plate than in the stationary plate are being used. The light construction of the stationary plates necessary for self alignment and the control of expansion has made them difficult to handle in the machine shop, and some trouble was experienced with resurfaced plates until a method was found to handle them in the lathe without deformation.

High-pressure oil for starting has been applied to one of these bearings but has not been used long enough to give us any definite ideas as to its value. A careful record is kept on the starting effort required for each machine having bearing of this type, and when it exceeds a certain standard the bearing is investigated for trouble. In the operation of these bearings, it has been found that the color of the oil, rather than its temperature is the best basis of judging whether the bearing is in trouble or not.

Guide bearings have been difficult to lubricate, due to their position. Trouble from vapor and leakage seems to be a common evil. Some relief has been afforded by the application of felt packing rings and vent pipes, but results are still far from satisfactory. Guide bearings with insufficient lubrication have been known to cause excessive vibration of the whole machine.

Spring type thrust bearings operate at considerably higher temperatures than the Kingsbury and for this reason greater care must be used in operating these bearings. Horizontal thrust bearings have been lost, due to too much pressure, as when seal rings of a single runner turbine would let through too much leakage, causing pressure back of the runner.

As a general rule, it appears that when going into guide bearings too little clearance is found. Most of the guide bearing troubles show soon after a machine is started, when the frame is still cool. The cold housing had not had time to expand the same as the shaft, so it may be that a little more than the standard clearance would be advisable. Guide bearings installed without sufficient clearances have been the cause of many operating problems. Oil is supplied by means of a geared pump to the generator shaft, or an auxiliary pump.

It is recommended that gages be installed in the discharge pipe and that they be equipped with minimum pressure contacts, so that an alarm would be sounded in case the pump stopped pumping.

Wickets are subject to wear, especially in those cases where the water carries sediment and where the adjustment is not perfect and deformation occurs due to trash. A hot galvanizing treatment protects it to some extent from erosion. Spring links on the gate mechanism were effective in protecting wickets from trash damage, as well as aiding in their adjustment. Wicket shafts in most cases show poor distribution of lubricating grease. This has proven worse in the case of vertical units. It so happens that some units have to be greased while the unit is in service. In these cases, water under pressure has been forced into the bearing and when grease is forced against the water pressure, examination proves that the grease takes the least resistance, being forced into the scroll case or forcing rings cut through to the draft tube. In many cases the wicket shafts show much rust and little signs of grease.

In some cases the grease ways through the wicket shafts have been changed so as to admit the grease very close to the packing, thus forcing it out towards the facing ring with tendency to exclude the water.

Experiments thus far show that a suitable grease applied on first assembly and regularly thereafter, about twice a week, has the best effect. It has been

found the most desirable to grease the wicket shafts with the unit out of order and the scroll case empty.

The high efficiency of the runner of the machine is primarily due to the runner, and it is sometimes wondered if the extra maintenance costs and many complications occasioned by its use do not offset any advantages it may have in the matter of efficiency.

The runners in use have a useful life of about five years. They could possibly be repaired and used longer, but it is doubtful if the expense balanced against their reliability would justify such action. The construction of these runners is a compromise between mechanical strength and hydraulic efficiency. The designers have favored high efficiency resulting in a runner with thin sections and high unit stresses in blades and mountings. This makes a runner with a fine initial showing, but internal vibration and inability to stand punishment cause the operating man to regard it with suspicion. Frequent inspections and an accurate record of the conditions found are essential to successful operation of this class of equipment.

There is a tendency to set up machines with too-small clearances between the runner and scroll case. An installation of 35,000-hp. wheels has presented problems that reflect back to the design. In this case runners have not given satisfactory service. The runners in question are bronze with steel wearing rings. A loose wearing ring on the lower side of the runner has been the cause of one runner change.

These runners show a good deal of erosion at the back of the vanes and also on all other surfaces exposed to the velocity of the water. Another problem in this installation has been the entrance of water to the turbine bearing. This has occurred at points just beyond the normal rating of the machine. A serious operating problem has arisen at times when machines have to carry overloads and to operate at low speed during system trouble.

Packing trouble with lignum vitae bearings has been found to be due to flax packing becoming so hard as to act on the shaft as an abrasive. Trouble has been caused by using inferior hard packing. Occasionally trouble will develop on account of someone tightening packing glands without using proper precaution, resulting in a scored rod or shaft, which in turn means more leakage and repacking. Too much importance cannot be placed on this subject for almost irreparable damage may result from the use of improper packing or any packing not properly lubricated, or set up. The remedy is to use the best packing for the particular requirement, and to be certain it is properly handled.

The lubrication of horizontal impulse units has presented no special operating problems. Pressure systems are installed in addition to the ring oiling system. The pressure system is normally used only for starting and stopping units. On one large machine of 28,000-kw. capacity the pressure system is sometimes used when the machine is on the line for long periods of time at light loads.

The lubricating of vertical reaction units presents a number of problems many of which are difficult to remedy and reflect back on the design. In general two systems are in use. The unit system where each machine has an oiling system complete within itself and the general or central oiling system. The central oiling system, using head tanks from which oil flows by gravity to the machines and thence through a filter from which it is pumped back to the head tanks, has much to recommend it, especially its simplicity and freedom from trouble. The installation in question has presented no operating problems. The idea of the unit system is to have each unit complete within itself so that there can be no general failure of the plant due to trouble with the central oiling system. In general the central oiling system is so simple that this is improbable.

In the second installation where a unit system is installed on three machines, numerous operation problems have arisen. The maintenance of such systems requires a lot of attention due to its complexity. There is a great deal of small equipment involved in such a system. Each unit has two belt driven and two motor driven pumps and there are two separate oil pumps. The motor-driven pumps are arranged to cut in should the belt driven pump fail. This is done by means of a pressure operated switch. These pressure switches are not always reliable.

With high-speed vertical machines, problems have arisen due to the escape of oil vapor that condenses on the windings. This has been remedied by the installation of a felt wiper on the top of the bearing case. Such a means would seem to be only in the nature of a makeshift.

The operating problems in connection with vertical machines can be lessened greatly by observing the following measures:

1. The central oiling system is more simple of operation than unit system.
2. Oil piping within the machine should be kept to a minimum with maximum accessibility.
3. All oil piping should be of extra heavy brass in the smaller sizes. Unions should be of the Navy type.
4. Swing joints should be used at all points where piping may be stressed, especially inside the machine.
5. The centrifugal oil filter is of the greatest value in keeping oil in good condition.
6. G.E. No. 800 varnish has been found to be very satisfactory in making up pipe connections that have been taken apart several times.
7. In unit system installation, simplicity will be maintined by keeping the oil sumps, oil pumps and motors outside of the turbine rooms.

Oil flow indicators on bearing lines with back pressure have not been very satisfactory, and standard oscillating disc water meters adapted to handle oil have been used quite successfully. This permits an adjustment of the oil flow to the bearings that is free from the disturbing factors encountered when adjustments are based on oil flow from the bearings. It also permits records of quantities of oil used per shift on each bearing, and definitely shows up any improper handling.

Automatic control of pumps handling lubricating oil has not been countenanced. It is believed that manual control is more conducive to close attention, and the automatic devices are limited to thermostats and level alarms that are purely supervisory in their action.

Turbine guide bearings are practically all provided with water lubrication of wood linings. It has been found advantageous to equip these bearings with facilities for forced grease lubrication. This keeps the bearing surface on the shaft in better condition and reduces maintenance.

Wicket bushings are all grease lubricated using standard fittings and grease guns developed by the automotive industry.

Lubrication is an important item and only good grease or oil should be used on any machinery. Also the proper lubricant should be used for a given purpose. At times a turbine regulator would appear sluggish when the real cause would be improper lubrication, and often not for lack of grease, but due to improper kind, or because the old style grease cup would not force the grease where it belonged. Changing to a pressure system, like alemite or zerk, and using a good grade of grease, remedies many troubles. With respect to oils, few are suitable for every condition, especially light or heavy oils. Where heavy oil performs well in one bearing it may be impossible to use in another, especially in thrust bearings where there is such a wide speed variation.

There are installations where the thrust and upper guide bearings are lubricated by oil supplied by a gear type pump geared to the generator shaft and located in the oil sump around the generator shaft. If the pump

fails the only means of alarm is overheating of the bearings, and due to not always being accurate the bearing may be damaged before the machine can be shut down after the temperature alarm has sounded. It is suggested that some sort of alarm for direct pump failure be installed so that the attendant can immediately supply oil from some auxiliary source, thus probably saving the bearing and also the shutting down of the machine until not in demand.

The lower guide bearings on a vertical unit, have a viscosity pump in the bearing unit with an oil sump around the shaft. Leaking of the water seal sucked all the oil out of the pump. Installation of street ells for air vents broke the vacuum and stopped the oil loss.

A direct alarm on the oil flow itself, in addition to the excess bearing temperature alarm, is suggested. Also the installation of an auxiliary oil supply which may be used with any one or more bearings.

Some trouble resulting from too little clearance on wearing rings has led to a greater tolerance than is often recommended by the manufacturers. Regular inspection to guard against rubbing is a recognized necessity and any change in alignment should be corrected at once. The clearance between the wearing ring and the scroll case should not be too close on large machines. Experience seems to indicate that a total clearance of about 0.040 in. is about correct. This will combine a higher efficiency with freedom from trouble.

Any change in the usual balanced chamber pressure warrants an investigation.

Considerable erosion takes place due to grit or other foreign matter in the water. Sand traps are used with good effect, but still there is enough grit left in suspension to give considerable trouble. One remedy would be to make the runner blades of greater thickness to withstand this wear, or to use a metal of sufficient hardness to resist it.

No trouble has been reported with braking equipment, if used properly, allowing the machine to reduce speed to approximately a pre-determined r.p.m., based on the speed of the braking drums, and not left on long enough at a time to cause excessive heating, as this causes expansion and contraction tending to loosen the plates.

On a small horizontal unit, an emergency braking system has been provided by arranging a heavy timer so that it may be pulled against the lower surface of the turbine generator coupling by a set of blocks.

Hydraulic braking of impulse units by directing a stream of water against the buckets in the reverse direction of the rotation has not been the cause of any operating problems. The braking of large vertical units by pressure of brake shoes on the bottom of the rotor is satisfactory in operation but not perfectly satisfactory in maintenance. This is largely a matter of design and may be remedied accordingly.

The brake cylinders are heavy and inaccessible. Trouble on a cylinder is frequently the reason for a machine outage of not less than four hours. The brake cylinders are situated in humid air and frequently freeze up. When applied they will not release until pried down with a bar. The cylinders could be made of lighter material and arranged to be easily and quickly removable. Outages by reason of the replacement of shoes would be lessened if shoes were arranged so that they could be slipped in from the side. They should be properly dovetailed and should have no hold down screws on top.

Draft tubes are very critical in their design and some trouble has been experienced with pounding, at heavy loads. This was thought due to the breakage of the water column when the vacuum at the throat ring passed a certain point. Some relief has been afforded by the application of automatic valves that break the vacuum when it becomes excessive. Later machines have this feature as an integral part of their design. Some experiments were made to limit the pitting of the runners at light load by admitting air to the draft tube automatically at this time. It was hoped that this would check the formation of gas pockets, rich in oxygen, at points where the water did not follow the contour of the wheel. Results were not very satisfactory and this practice has been discontinued.

Two other companies report excessive hammer in the draft tubes at certain loads; cause unknown. As a remedy they always carry a load above or below the critical point.

Due to inherent vibration in units of certain type it has been found best to keep the machine room floor and structural parts of buildings free from any contact with the machine or its foundation. In several cases it has been necessary to change the length, and accordingly the period of vibration of beams and girders so that they would not resonate with vibrations orginating in the machines.

It has been our experience that bypass valves, as put out by the manufacturers are very difficult to close and are usually so designed that they consume considerable time in being operated. In one installation some trouble developed on 6-in. bypass valves. These valves had a brass seat pinned to a cast iron wedge. The seats were torn off by the water flow. Solid brass wedge gate valves operating on heads up to 2,100 ft. have been the cause of no operating problems.

Needle-type bypass valves up to 8 in. in diameter have not caused any operating troubles. Considerable time has been lost during the shut-down of plant, for turbine inspection, gate repairs, etc., due to having to drain a very long woodstave penstock. A valve installation ahead of the turbine is nearly always desirable.

Bypass valves are installed for an important function. In two cases reported, two 18-in. bypass valves, wedge type, were installed on units operating on a normally low head of some 120 lb. From the first time the units were started the valves were inoperative due to their design. The question sometimes arises whether or not a bypass valve is necessary on the low-head systems.

Hydro-Plant Equipment, Partial and Full Automatic Operation

One company reports that on their load-control equipment three wires are used between the power house and the forebay, one wire being a common. If an open circuit occurs on one of the outside wires the needles would open full and if on the other wire, they would entirely close. In one condition the forebay would be drained, in the other it would overflow, as the equipment only works when there is an unbalanced condition between the rheostat at the power house and the one at the forebay. This company is installing a device that will close the needle and sound an alarm if the unbalanced condition exceeds a certain amount.

A relay of the contactor design and requiring only a small amount of current to operate could be cut in each balanced circuit with contactor holding other balanced circuit closed, so when either circuit opened it would open the other relay. This arrangement would clear balanced relay so needles would not close or open, in the event of either circuit being opened by line going down.

On a recent installation "park cable" was used on the load control equipment between the power house and the forebay. The cable was laid on top of the penstock and securely fastened thereto. When the anchors were poured conduit was installed for the cable to pass through. This is considered a much better arrangement than overhead wires.

Needle valves in time-delay relays sometimes become obstructed by dust particles which interfere with the timing and load changes. Special arranged flat chambers should be installed so that oil could be used to prevent freezing. The water surface in the float chamber should be fairly quiet or needle mechanism will hunt. The needle motor is equipped with a solenoid brake. It was found that the frame and mechanism

of the brakes are too light, and all brakes had to be reinforced.

The rheostat cable should be of the best material and pre-stretched. The limit switch should be so arranged that adjustments for different loads could be readily accomplished.

Deflectors and load rejecting equipment have given some trouble from leakage at the glands around the cylinder of the deflector. Cup leather gaskets were used and the piston rods were made of steel. When the deflector is in such a position that the water is on the wheel, a portion of the piston rod is in the cylinder, submerged in water, where testing is only performed once a week. Often this rod is submerged for a one-week period. During that time rust accumulates and in a short time the rod becomes so rough that it is difficult to make a cup leather hold. It is recommended that the piston rod be covered by a brass or bronze sleeve. Some trouble with the deflector operating too slow was experienced. It has mechanical and electrical control valves which were at first in series on the discharge pipe from the cylinder; later these were connected in multiple and so arranged that the pressure is released under the hydraulic jacks when they operate.

The mechanical overspeed consists of a centrifugal device on the shaft which at a pre-determined speed operates the valves located under the shaft and at the same time trips an alarm circuit.

It is believed that a great improvement could be made in a centrifugal device. For instance, assume the valves to trip, say at 340 r.p.m. At 325 r.p.m., the arm may be striking the valves but does not actually trip out until the speed reaches 340 r.p.m. This is a very crude arrangement. The valves have a piston and cup lever in same. If operated quite frequently it never sticks out, but if allowed to stand for a week it is quite likely not to function. The location of the valve should be such that if the pipe broke there would be no danger of flooding the generator pit.

A great improvement could also be made on the electrical over-speed device and its hook up, especially so when used in an impulse-wheel type plant. In that case the generator shaft is generally hollow and special connection has to be made to the shaft. The connection has to be carried through the wheel housing and a suitable bearing arranged; this bearing should not be mounted on the wheel housing on account of the bypass being located inside. The shaft has to be protected from the spray from the nozzle.

A flexible coupling is necessary to take care of the end thrust of the main shaft. The overspeed device itself should be so designed that the contacts are visible and readily adjusted.

It is believed that in a partial or full automatic plant penstock low-pressure alarm equipment should be installed. It is just an extra precaution, and if the other apparatus seems reliable it is not necessary, but if some of the other apparatus did not function, it would readily justify its installation.

Auxiliary Power House Equipment

Cranes should be provided with power in such a way that they are not dependent upon any machines they are called upon to serve. Shut-downs, intentional or otherwise, often tie up the cranes when they are needed the most. Alternating current motors of standard voltages have proven the best for this work as they are adaptable to many conditions not met by direct current motors.

The crane problem in recent installations simmers down to one bad fault. The constructors of the power houses made little or no provision for the crane operator to make his exit, except that he ran the crane to its pre-determined landing. He could come down a ladder or a stairway. It happens that frequently it is necessary to leave the crane tied up over night or during meal hours. The only way for the operator to do is to climb to the crane tracks and balance himself or crawl along to the landing end of the crane. Some means should be provided for a safe exit from the crane at all central positions or completely along the building adjacent to crane carriage.

Considerable discussion has been had at our recent meetings on crane design looking toward decreasing the cost of the building structure. There is such a thing as carrying this too far, which has occurred in a recent installation where the head room is so limited that the cost of maintenance will be increased.

At quite a number of plants the installation of a large compressor is not justified but a small portable compressor is economical and it can be used to a good advantage in cleaning, painting and testing.

Filters are carried in several isolated plants and a portable one for the others. No trouble with their operation has been experienced. In some of the plants ejectors are installed in the pits, but a portable motor-driven pump is provided for use in emergency.

Air compressors for power plant use are called upon to do some very important work and they should be as reliable as the main equipment. There has been a tendency to use compressors of an inferior grade that would be more suitable for a rough construction job of short duration. The average interurban car has a better air compressor than most hydraulic power plants.

A tank of the size to hold all of the oil of any one piece of apparatus having oil to be filtered, should be provided. This storage tank should be piped to a point where filter is to be located. Another pipe should be run from filter to location of points where hose can be attached to apparatus to have oil filtered. This arrangement allows outdoor switches to be overhauled and oil filtered in a rain storm. It is an advantage to have the tank located higher than suction on filter, so gravity will help pump suction. A good hose of number of ply fabric and not too much rubber should be used as heavy rubber inside tends to swell under use in oil and retards suction.

Office records show a needless duplication when machine tools are installed in any other location than the central shops, but great economies in transportation and power plant maintenance are realized when a reasonable number of machine tools are provided.

Machine shop equipment for a remote power plant, or for a group of plants should consist of the following:

One 24-in. motor-driven engine lathe with 8-ft. bed.

One 36-in. motor-driven shaper.

One 36-in. motor-driven universal drill press.

One medium heavy-duty double overhung motor-drive emery wheel.

One welding and cutting outfit, complete.

One motor-driven power hack saw.

One medium size motor-driven band saw with necessary accessories for each—for power plants without access to local machine shops.

The question of pipe dies, vices, drills, taps, angle plates, surface plates, reamer, and wrenches is a matter of selection to suit conditions and requirements as the case may require and they can be added to from time to time.

It is recommended that the manufacturer supply two sets of wrenches, etc., with his large equipment, because when the general construction is finished there are no tools left for the maintenance and operating men to work with. It is suggested that the manufacturer be more liberal with prints and operating details for his equipment. It is more apt to function properly if the operating man understands it thoroughly.

The selection of spare parts for installed power equipment depends on the installation as a whole. It is a hard matter to pre-determine, for what one engineer would deem necessary, another would not. Most companies carry spare equipment in many cases for years without need. Before they are needed a complete

change in design may occur or reconstruction take place. In such cases the stock in spare parts is a total loss, and it is a question whether a set of spare generator coils or a spare transformer would be justified for insurance.

The necessity for carrying oil switch parts, exciters and collector rings, brushes, insulators, nozzle tips, needles, wickets, control links, spare Kingsbury shoes, bearings, etc., depends on size and importance of the station.

Hydraulic Plant Operating Troubles Due to Low Temperatures

By GEORGE A. HUNT*

This paper describes the types and characteristics of ice formation and shows how ice interferes with normal operation of hydro-electric equipment in cold climates. Data are given outlining the practices and remedial measures that have been developed in this regard in Norway, Sweden, Canada and in eastern United States. Ice and snow troubles in the operation of a typical California project are detailed at some length together with a brief discussion of the remedies that have been or may be applied. The article closes with a summary of remedial measures that are applicable as a whole or in part to any project where low temperatures cause periodic interruptions in operation.

THE EFFECT of low temperatures on hydraulic plant operations with special reference to the handling of snow and the various forms of ice in high mountain developments is a subject on which comparatively little information is available. Freezing temperatures create problems which many power companies have to contend with.

Remedial measures that must be taken on many projects to prevent interference with normal operations due to accumulations of snow and ice or due to the freezing up of mechanical devices add a substantial amount to the operating costs of such developments during the winter months. Most of the operating companies in the West have looked upon these conditions merely as imposing an additional burden rather than as representing a problem in economics wherein the carrying charges and operating expenses of proper remedial devices should be balanced against the annual value of power lost plus all items of extra expense that accrue through lack of efficient means for combating the effects of extreme cold.

Ice Formations and Their Characteristics

The maximum density of water occurs at 4 deg. C., or 39.2 deg. F. At that point the density of water is unity, and is the standard to which all other substances are compared. Water expands slightly at temperatures both above and below that point. At the freezing point, or 32 deg. F. (0 deg. C.) the density of water is 0.999868; at its boiling point 0.95. The density of pure ice is 0.92. From these figures ti may be seen that when water is cooled from 39.2 deg. to 32 deg. F. its expansion is very slight. Nevertheless it is sufficient to exert an important influence on the formation of ice, as it is this expansion which causes the cooler water to remain at and freeze on the surface.

Local conditions and manner of heat transmission, or radiation, determine the kind of ice that is formed. Ice exists in several forms, commonly called in this

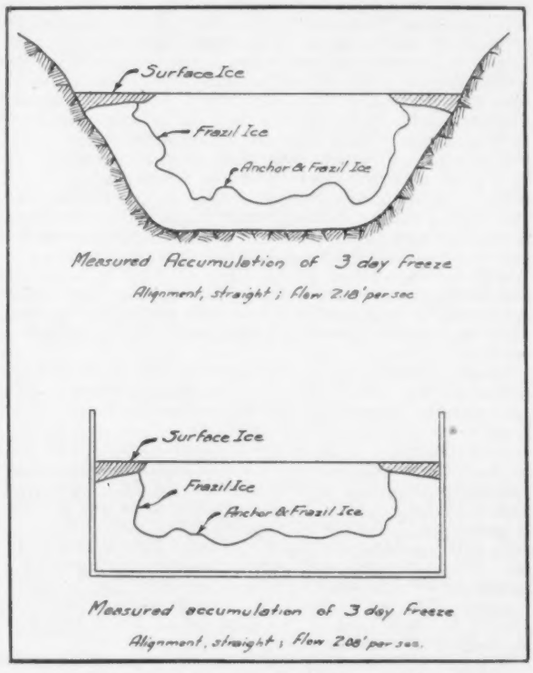
Surface Ice
Frazil Ice
Anchor & Frazil Ice
Measured Accumulation of 3 day freeze
Alignment, straight; Flow 2.18' per sec
Surface Ice
Frazil Ice
Anchor & Frazil Ice
Measured accumulation of 3 day freeze
Alignment, straight; Flow 2.08' per sec.

Fig. 1. Typical cross-section of original El Dorado Canal of the Pacific Gas and Electric Company, showing measured accumulation of a three-day freeze.

locality (A) Surface, sheet, or cake ice, (B) Frazil ice, or sludge, and (C) Anchor, or bottom ice.

Surface Ice forms on any sheet of still or moving water under suitable conditions. When the air temperature is lower than that of the waters of a reservoir, heat is radiated slowly from the surface of the water into the colder atmosphere and the surface water is proportionately cooled. Upon cooling, the water contracts and sinks due to its increased density, forcing the warmer under water to the surface to be cooled in turn. This circulation and cooling process continues until the entire body of water has reached its maximum density at the temperature of 39.2 deg. F. when circulation ceases. Surface water thereafter continues to give up its heat and due to its slightly lower density when cooled below 39.2 deg. F. remains at the top.

If the air continues cold enough the surface water is reduced to 32 deg. F., gives up its latent heat of fusion and a further reduction of a few thousandths of a degree causes the formation of ice. The ice sheet ordinarily forms first at the banks where radiation is at a maximum, and builds out toward the center of the body of water. Although ice is a very poor conductor, heat from the water immediately adjacent to the under surface gradually is conducted through the ice to the outside air and the ice sheet slowly thickens on the underside. The main body of water, however, is protected by the ice sheet and normally will remain at 39.2 deg. F. The stored heat in this water may be used to great advantage in handling snow and ice, as draft of the warmer under waters from storage in a reservoir will keep a flow conduit clear for many miles.

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* Report prepared for hydraulic power committee, Engineering Section.

The formation of ice sheets in rivers, canals and open conduits follows the same general process except that the turbulence and constant circulation of the flowing water retards surface ice formation. Ice does not ordinarily form in a flow channel until all waters of the stream reach a point near 32 deg. F. Ice formation starts at the banks and gradually develops thick "haunches" at these abutments. The underside of an ice sheet in a relatively narrow channel becomes a parabolic arch due to thickening at the banks. Surface ice expands when and after forming and, if it is allowed to close in a continuous sheet, tremendous stresses are developed which may do serious damage to the side of the conduit or to any structures with which it is in contact.

Frazil Ice is in the form of fine needle-shaped particles that have a tendency to agglomerate in masses lying at all angles "like nails in a keg." It develops rapidly in waters agitated by wind action or by rapid velocity of flow through rough, broken channels. The needles form by super-cooling of the body of water in contact with air below 32 deg. F., principally on cloudless nights. It is found that each crystal forms around a minute nucleus of sand or other material, often microscopic in size. The ice needles attach themselves immediately upon contact with each other with the underside of surface ice or with any obstruction in the channel. Compact masses of these ice needles

Fig. 2. American River channel above El Dorado intake. Frazil ice accumulation of two nights.

build up with surprising rapidity, seriously reducing the capacity of flow conduits which may be entirely blocked unless immediate remedies are applied. Fortunately, this form of ice is quite sensitive to slight increases in temperature, which cause it to disintegrate and lose its attachment to the ice sheet or sides of the conduit.

Anchor Ice is the most troublesome form of ice encountered in hydraulic operations. It forms in rough, open water, in streams or rapids, or in conduits where the flow is turbulent, principally during clear, cold nights when radiation is at a maximum. It forms in irregular masses of slush composed of minute flat and spinular crystals or flakes of varying sizes and somewhat similar in appearance to the frazil ice needles. It accumulates in great masses on the sides and bottoms of channels. It will not form beneath an ice cover, in covered channels, nor in any place where it is possible to reduce heat radiation. Its inherent tendency is to attach itself to the bottom of a conduit on any dark-colored projection. It freezes on so tightly that a mass of it when loosened will pick up or tear loose and carry away a considerable mass of rock or gravel from the bottom of the conduit. It frequently consolidates into continuous, riffled sheets that are as compact and hard as surface ice. This condition is found particularly in the bottoms of high-velocity flume sections.

Foreign and Eastern Practices

In the colder countries of Europe, particularly in Norway and Sweden, much thought has been given to the ice problem because of the usual long periods of intense cold. Entire developments in these countries must be carefully planned along lines which tend to minimize interruptions to plant operation.

The fact that neither frazil nor anchor ice will form under an ice cover is used to advantage by fostering the development and the maintenance of an ice sheet over conduits, canals, forebays, and even in river channels by artificial methods. In Sweden streams have been developed throughout their entire length into a series of steps formed by impounding dams that create successive ponds of stored water. The underwater from the storage thus created is drawn down from pond to pond and so kept entirely free from cake ice and, due to its warmer temperature, the danger of formation of frazil or anchor ice prior to its use through the hydro plants is eliminated.

Where an ice sheet can be used in a canal section, the flow conduits are made relatively wide in proportion to their depth and the formation of an ice sheet accelerated by the arrangement of a ribwork of logs floating on the surface of the water. Frazil ice immediately becomes attached to these logs and forms a nucleus upon which the ice sheet develops. An ice sheet once formed in this manner becomes more or less permanent for the entire winter period. When this scheme is impracticable a deep narrow canal section is used because whatever stored heat there may be in the water is retained longer in the larger, deep body of the flow section. Contact of the water with the deeper soils of a conduit of this shape also is advantageous due to the greater warmth of the deeper earth. Special efforts are made to obtain uniform velocity and to eliminate all possibility of disturbance in alignment and grade. Structures such as piers, sluice boxes, weirs, rapid flumes, etc., all have a tendency to increase the ice hazard and their use is avoided as far as possible.

In Norwegian developments it has been found that the best means to prevent anchor and frazil ice from blocking screens is the electric heating of single bars, or groups of bars, by passing current through them. For common screens with water velocity of from 1.3 to 2.3 ft. per sec., and a bar section of from 0.6 to 1.0 sq. in., sufficient heating of the bars has been obtained with from 250 to 300 amp. per bar. Tests made at seven plants in Norway indicated that the average electric consumption was from 5 to 6 kw. for each 35 sec-ft. of water passing through the screens.

A test made at a plant in Sweden indicated that the required electric energy to heat steel-bar screens to keep them free from ice amounted to only 10 kw. per 160 sq. ft. of screen for velocies ranging from 2.5 to 3 ft. per sec. which is equivalent to a flow of about 440 sec.-ft. In that case the power consumption was only a fraction of that cited in the previous case.

Fig. 3. Section of old El Dorado ditch showing surface ice, floating frazil and bottom ice loosened by slight rise in temperature.

These instances are not given as a basis upon which any formulae might be determined, as each situation and its remedial requirements depends entirely upon local conditions. The data indicate, however, that consumption of power for this purpose would be a relatively small percentage of the output of the average Western plant using large flows of water through high heads.

In some climates exposed penstocks take on an interior shell or coating of ice which, when loosened by a rise in temperature of the water or of the outside air, may be carried down to the plant either entirely blocking the penstock with consequent damage, or causing serious injury to turbines or water wheels. This has been successfully remedied by burying the pipe, covering it with a heat-insulating material, or providing a cover creating a dead-air space around the pipe.

Experiments have been made on the installation of electric heating elements in the masonry adjacent to gates and other mechanical devices to prevent clogging with ice. Heating elements of 1 kw. capacity spaced from 5 ft. to 6 ft. apart along masonry structures have proven adequate to preclude the possibility of ice growth. This method has been beneficially applied to roller gates, radial gates and many similar structures. Where power plants are immediately adjacent to dams the operating mechanisms of all types of devices subject to freezing have been efficiently protected by housing them and using hot air from the generator to keep them warm.

A Canadian company has used steam heat successfully to eliminate troubles caused by the adhesion of frazil ice to screens, turbine gates, etc. A line of steam pipe laid against the face of the screen just above the water level has given satisfactory results. In the same installation steam was applied by small pipe lines to the wheel housings whenever the units began to lose capacity. During four winter months only 20 tons of coal were required to prevent interruptions due to ice blocking in an installation utilizing a stream flow of about 1,670 sec.-ft. Experiments carried out on the same project also proved that electric heat could be used effectively and economically.

A recently published article described a practical and economical method developed by the Indiana Hydro-Electric Power Company of using compressed air to prevent ice formation along the flashing on the spillway lip of a diversion dam in the Tippecanoe River. The spillway is 225 ft. long and it was found that 22 air jets spaced on 10-ft. centers along the upstream face of the dam 15 ft. under water and each delivering a steady flow of unheated air maintained an open channel in front of the spillway lip which formerly had been kept clear by chopping.

Air is delivered to the jets from a compressor developing a pressure equivalent to the hydrostatic pressure at the jets plus velocity and friction losses in the pipe lines. The compressor is operated to deliver 13 cu. ft. of free air per minute. This unit and its motor are mounted on an adjacent pier and housed for protection against rain and snow. No difficulty has been experienced either with the compressor or with air lines due to low temperatures. The sizes of the jets were adjusted to obtain a uniform flow from each jet. Proper spacing to accomplish perfect results was determined by experiment.

It would seem that this idea could be applied in many cases where it is desired to prevent formation of ice at critical points in still-water basins, such as around gages, outlet works, etc.

Typical Experiences In California Operations

A typical example of the influence of freezing temperatures on the operation of high-mountain conduits in California exists in the Eldorado Canal which diverts from the south fork of the American River at an elevation of 3,915 ft. above sea level. This conduit has its intake on the south bank and so traverses the northern slope of the mountains. For the first 12.5 miles it is in a deep river canyon running through heavy timber under the shadow of high bluffs where it seldom is reached during winter months by direct rays of the sun. It is in this upper section that the principal ice troubles occur. The conduit then comes out of the canyon and for the next ten miles meanders through scattered timber and a lighter brush cover, dropping down the ridge through flatter, open country. The beds of the tributary streams and the main river above the intake are steep and rugged and the waters feeding the canal are from a watershed ranging from 4,000 to 10,000 ft. in elevation and are chilled to a low degree before diversion.

The dam at the intake forms a pond only 300 or 400 ft. long which usually is frozen over during the winter. Even though no storage is afforded by this small body of frozen-over water, and its benefit due to the ice cover is theoretically negligible, the existence of the pond nevertheless is beneficial to the operation of the canal inasmuch as no ice troubles ever have occurred in the first half-mile of conduit below the intake. If a deep, substantial storage existed at the intake it undoubtedly would be effective in eliminating ice troubles for a major portion of the upper 12.5 miles of canal.

Observations made along the conduit show that anchor ice first forms on dark rocks and other objects in the open-ditch section. It next forms in the flumes on the corners, ends, and nail heads of the bottom battens, then on corners and rough spots of the side battens. The accumulations grow rapidly on the sides due to the agglomeration of frazil ice which permeates the entire flow of water in the conduit at the time that anchor ice tends to form. Subsequent accumulations are the growth of the frazil and anchor ice which spread rapidly on the initial formations over the entire wetted perimeter until the waterway is so completely choked that the delivery of water through it is impossible. Such accumulations in the Eldorado Canal have grown from mere traces to complete stoppage of the canal within a single night.

Where the velocities are high, particularly in the flumes, the bottom ice gradually is congealed into a very solid and hard ice sheet with its surface in the form of regular lateral riffles. It is not practical to attempt to remove this formation as it has been determined that when the flow is interrupted the last waters, instead of draining out of the canal, turn to ice and create an even worse condition. It is best to maintain the canal in full operation as along as possible as a change in weather may at any time relieve the ice congestion, or at least aid in taking care of it.

After a freeze-up the ice must be removed from the canal progressively downstream from the intake. In order that the maximum amount of ice-free water may be available in the sections being cleared, sections between ice sluiceways are worked clear of ice in rotation. It is very difficult to keep the sluiceways in

Fig. 4. Typical flume section on original El Dorado canal showing accumulation of anchor and frazil ice.

working condition as they are particularly susceptible to freezing and clogging by the attachment of anchor and frazil ice on the stream side and by the freezing of such waters as may leak through them. They must be kept constantly free for operation in anticipation of sudden thaws and the resultant danger of snow and ice jams.

It has been found that a substantial crew of men armed with a combination ice-pick and chisel can clear about five miles of this canal of ice accumulation in a day. As high as 40 sec.-ft. of water is required to carry away the ice loosened by such a crew. When bottom ice is freed by changes in weather or by flushing with ice-free water it picks up large quantities of rock, gravel and silt which are carried downstream and dropped in flume sections and elsewhere along the canal, or which may even be conveyed into the forebay. The tearing out of this material from the bottom of the ditch often opens up seams in the canal section and greatly increases leakage losses.

The original Eldorado Canal had a smaller capacity than the present one and occasional trouble was experienced from direct snow fall. In 1913 the snow fall amounted to 73.5 in. of snow in three days and completely blocked the canal. A more intense storm of short duration occurring in February, 1919, during which 18 in. of snow fell in twelve hours again also blocked the canal. Floating snow in the conduit accumulates very rapidly and the stoppage has been known to travel up the canal at the rate of five miles per hour. These stoppages are apt to occur in any canal having less that about 200-sec.-ft. capacity. With larger capacities there usually is ample flow and velocity to permit effective sluicing.

Since the enlargement of Eldorado ditch to 155-sec.-ft capacity, largely through extensive lining, much less trouble has been experienced with ice and snow. Sluice gates provided when the canal was enlarged were designed upon the theory that gates do not freeze up due to collection of anchor ice when they are submerged from six to eight feet and if further protected on the downstream side by a dead-air space. These work well, but do not entirely solve the problem. In general the greatest difficulties are experienced when there has been a continuous cold spell of a week or more with temperatures approximating 32 deg., followed by a sudden fall in temperature to a point well below freezing for ten or twelve hours. Normally it seems to take several days of freezing weather to result in serious ice trouble.

Fig. 5. Typical accumulations of surface, frazil and anchor or bottom ice. Canal empty.

Another cause of trouble that has not been mentioned heretofore is the formation of an ice lining in the 60-in. steel siphons in this conduit. Both siphons have upon several occasions frozen up until there was only about 18 in. clear inside the ice ring, and this freezing occurred in spite of the maintenance of heaters at both the intake and outlet of each.

The costs of handling snow and ice on the canal are at least illuminating, although complete details are not available. The cost of extra labor, representing only about 75 per cent of the total cost of ice and snow removal along the canal for the past three seasons, was about as shown in Table I.

Fig. 6. Typical ditch section on original El Dorado canal showing surface, frazil, anchor ice and sheet ice in the bottom from waters frozen when the canal was drained.

TABLE I

Average Annual Cost of Ice Removal On Eldorado Canal

	1925-6	1926-7	1927-8	Average
November	$ 430	$ 110	$	$ 180
December	514	2,306	100	973
January	1,600	1,758	1,500	1,618
February	390	662	600	550
March	6	138	.....	48
Total extra Labor	$2,940	$4,974	$2,200	$3,370

Other items of expense such as cost of fuel, equipment, etc., amount to about 25 per cent of the total cost. It is safe, therefore, to estimate that the annual cost of snow removal on the Eldorado Canal is approximately $4,500. These are direct "out-of-pocket" costs and do not include the value of lost power, etc.

As possible remedies it is thought that the covering of all flumes for the first 12.5 miles of this conduit would keep the ditch sections clear, since in passing through such closed sections snow, frazil ice and anchor ice would be melted almost entirely and the sections of ditch between flumes are not long enough to permit serious freezing again. In addition to this a substantial percentage of the snow entering the canal would be eliminated.

Draft on storage is probably the cheapest and most effective remedy for ice troubles. The underwaters in storage, as previously explained, have a practically uniform temperature of 39.2 deg. F. The latent heat of fusion of water is 144 B.t.u. per pound of water, or approximately 9,000 B.t.u. per cu. ft. This water also contains 7.2 deg. of stored heat, amounting to 450 B.t.u. per cu. ft. One cubic foot of water drawn from storage, therefore, contains 9,450 B.t.u. of heat that is available for the elimination of ice troubles when this water is drawn down and mingled with canal flow.

If water from storage must flow through many miles of river channel before reaching the conduit a considerable portion of this heat content may be lost. It is a matter of estimation and calculation as to how much heat will be available in this water at the canal intake. It also is a matter of estimation as to what percentage of the water flowing in a conduit is turning to ice and how much heat is required to prevent its

conversion. It then is a simple computation to determine how much water must be drawn from storage to supply this required amount of heat. An ideal situation would be one in which a small quantity of water from storage, or from warmer side streams, could be injected into the canal flow at proper intervals along the line of the conduit. It is especially important that such deliveries of warm water be made into a conduit above the intakes of siphons that are subject to freezing.

Operating difficulties resulting from the freezing of mechanical devices in and about power plants need not be discussed at length as there are many practical remedies which can be applied in each case. Valves along penstocks ordinarily may be protected completely by housing to provide dead-air space that may be slightly heated in any desirable manner, or by the injection of oil to displace the water under the valve. The small piping at Venturi meters, bypasses, and similar points in penstocks may be protected either by such housing and proper heat insulation, or by application of electric or other heating coils. Mechanical devices in the pits under water wheels and in other compartments under power plants that sometimes are subject to freezing may be taken care of by utilizing hot air from the generators. Outdoor switches may be kept clear by providing sufficient hoods over the moving parts and contacts.

Summary of Remedial Measures

The best remedy against the blocking of open conduits by snow and ice undoubtedly is the release of the relatively warm waters drawn from deep storage reservoirs. Where possible such water, or water diverted from warm side streams, should be injected into the conduit at intervals along its traverse. A reservoir of substantial capacity at the intake and storage ponds at or near the intakes of side stream diversions would be ideal for continuous operation.

The covering of flumes and, if necessary, some open ditch sections is beneficial in preventing the formation of anchor and frazil ice and in minimizing trouble

Fig. 7. Concrete-lined section of El Dorado showing effect of snow on right side and ice accumulation on left side in slow-velocity section.

from snow slides. Changes in grade and alignment or the construction of structures within the flow channel should be avoided in order to minimize turbulence. Smooth linings are most beneficial.

The use of electric current or steam to warm structures such as racks, grizzlies, gates, valves and other devices to prevent freezing or clogging has proven to be an economical remedy for local trouble. The release of compressed air in still-water basins has been established as effective in preventing the formation of ice at points where open water is desirable.

Housing to provide dead-air space, heated if necessary, is effective protection for penstocks and siphons, Venturi piping, valves, etc. If temperatures are not extreme, earth covering or other heat insulation may be sufficient. It may be mentioned that such insulation is also a protection against extreme heat. Due to its availability, hot air and warm water may be used in and about power plants to prevent loss in efficiency and to keep auxiliary apparatus in operating condition.

Protective Coatings for Hydraulic Structures*

Pipe lines and penstocks are important, but represent only a part of the many hydraulic structures that depend upon protective coatings for low maintenance cost and length of service, and to a limited extent for their efficient operation. Therefore, the subject "Protective Coatings for Hydraulic Structures" was the natural outgrowth of the work done last year by the subcommittee on penstock painting.

Information has been collected from operating companies, paint manufacturers and others on the causes of decay and corrosion, and the most effective preventive measures to take. The various kinds of protective coatings have been classified and discussed. Experience with different types of structures such as flumes, pipe lines and intakes, has been reported as well as tests designed to discover if possible the best materials and methods to use to prevent corrosion.

An extensive bibliography which includes a list of standard paint specifications, has been made a part of the report.

PROTECTIVE coatings for metals on hydraulic structures are applied for the protection against one or both of the following: (1) corrosion of metal, and (2) erosion. The coatings that are of practical use as protectors for hydraulic structures may be grouped in classes as follows: (1) metallic coatings, (2) paints, (3) bitumastic mixtures and tars, etc., (4) cements.

Protective coatings are engineering materials ust as much as the steel or the main members of a structure, and the subject should be given more careful attention and deliberate study.

Corrosion

In the "Report of the Subcommittee on Penstock Painting," (1928) the generally accepted theory of corrosion was briefly outlined and reference is now made thereto.

Inhibition and Stimulation of Rust.—It is well known that soluble chromatic or alkaline substances such as caustic soda or lime placed in the water will prevent rust; the iron no longer having a tendency to go into solution will stay bright and clean. Such materials are called "Rust Inhibitors." Some pigments, due to acids they contain, when in water cause rapid corrosion of the steel; such materials are "stimulators" of corrosion. Many carbonaceous pigments are of this type.

The Effect of Moisture—Hardly any material used by mankind is absolutely dry. All oils have a certain amount of moisture content. Careful experiments have shown that linseed oil films, even after they have oxidized and hardened, have the power to a certain extent of absorbing water from the atmosphere. Furthermore, it is a property of water to become saturated with the gases of the atmosphere, therefore in a protective paint applied to metal there are present

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* Report of subcommittee of hydraulic power committee, Engineering Section. C. M. Mardel, chairman. C. L. Davis, J. W. Jourdan, Hector Keesling, E. D. Sismey.

at all times the elements necessary to carry on the corrosive process and reactions.

Due to this softening or absorptive quality of almost all materials those that are the hardest or least absorptive will give the most protection; and so metallic coatings should and do provide very good protectors.

Metallic Coatings.—These may be classified as (a) molten dip (galvanizing), (b) electroplating, (c) sherardizing, (d) metal spraying (hot), (e) mechanically applied (copper clad).

Taking the first and most common:

Galvanizing.—This consists in dipping the article in a bath of molten zinc after having most carefully cleansed the surface. As in all protective coatings the proper preparation of the surface to be coated is of primary importance. This is particularly true of galvanizing, and great care must be exercised in seeing that this is very thorough or the metallic film will not adhere. Galvanizing is perhaps the best protective coating for hydraulic structures but its application is limited to the size of the dipping tanks and also there is a tendency for certain shapes to warp during the process, channels being particularly susceptible to this owing to the difference in sectional area of the web and flanges.

Units separately galvanized cannot be hot riveted as this destroys the coating in the vicinity of the rivet. They are therefore bolted with galvanized or sherardized bolts. Fabricated articles are often riveted and galvanized afterwards as a unit; the surfaces that are in contact therefore do not get coated but a continuous film is built over the two pieces. If there is a subsequent vibration or distortion this film may crack and rust may form between the surfaces.

The American Society for Testing Materials has prepared tentative specifications for zinc (hot galvanized) coatings on structural steel shapes, plate bars and their products; serial number A-123-28T, which covers the field very well. The society also has established standards for the testing of the zinc coatings.

Galvanizing, if it be poorly done will give but poor service. It requires careful workmanship, adequate and proper equipment and first class materials to obtain lasting results. This necessitates careful inspection. At present, The American Society for Testing Materials is conducting an extensive test on galvanized sheets, the test-racks being located as follows:

Date Set Out	Location	Exposure
October, 1926	Brunnot's Island, Ohio River, Pittsburgh	Severe industrial
October, 1926	Altoona, Pa.	Medium industrial
October, 1926	Penn. State College, Penn.	Rural
October, 1926	Fort Hancock, Sandy Hook, N. J.	Sea fog
November, 1926	Key West, Florida	Tropical

At each location are a large number of plates of different manufacture and weight of coating and the tests should bring out some reliable information.

Electroplating—This is the process of applying a film or coating of protective metals to the article by making it a cathode in an electroplating bath. These baths are generally a solution of complex salts containing the metal mainly in the anodic condition, as the simple salts of the protective metals generally produce too coarse a structure to constitute a protective film. One of the disadvantages of the electroplating process is the tendency for the most prominent parts to receive an undue amount of coating while the cavities receive very little.

Copper plating of the moving part of penstock expansion joints has been very successful and efficient, by eliminating the rusting of the machined surface. The smoothness is maintained and the packing is not damaged by abrasion on the rusty steel. The cost of this method of protection is high and therefore only supplied in particular cases.

Sherardizing.—This is the process of coating the article with zinc or aluminum by heating (250°-400°C) in metallic dust in rotating drums. It is very common and successful for small articles such as bolts, nuts, clamps, washers, etc.

The colorizing process of obtaining an aluminum coating by heating to a very high temperature (800°-1000°C) in ovens is similar to sherardizing.

Metal Spraying.—Hot or Schoop process. A spray consisting of tiny globules of molten metal is directed against the surface to be covered by means of a so-called "pistol" which is held in the hand or in larger sizes on a stand. The pistol contains what is virtually an oxy-hydrogen blowpipe. A zinc wire is fed automatically from a reel attached to the pistol directly into the flame at the required rate. The zinc is vaporized and blown out of the pistol; the metal condenses to form the tiny globules which actually constitute the spray. In the later designs electricity is used for heat. The advantage of this process is that the coating may be applied at the job after assembling irrespective of the size of the article; it should be useful as a means of repairing or patching up galvanized work.

Mechanically Applied.—Copper clad is the most commonly known example of the work. Sheets and wire are made by working from a steel ingot that has a copper jacket cast around it. Small shapes, tees and angles are sometimes lead clad.

Bulletin No. 80 of the U. S. Bureau of Standards, "Protective Metallic Coatings for the Rust-Proofing of Iron and Steel" deals very well with this subject and gives numerous other coating processes. It also contains a good bibliography on the subject.

Paints

In selecting paints for use in hydraulic structures, we must find an article that will withstand severe conditions of climate, immersion in water, and continuous and alternating, and often sever, erosion due to velocities and impurities in the water. Most commercial paints are made to withstand atmospheric conditions and are not designed for water conditions; also, decorative requirements influence the design to the disadvantage of strictly protective purposes.

There are materials, such as dark resins that make a good ingredient but owing to their effect on the color, are excluded from most commercial paints. There are unlimited combinations of paints, varnishes, enamels; some of excellent quality are most successful under certain conditions.

Exhaustive tests have been carried on since 1896 by several capable organizations. Some of these tests extend over several years. The American Society for Testing Materials has conducted some very careful tests and the results are given in the various committee reports of that society. (See appendix on test data.)

Iron Oxide Paints.—Red iron oxide has always been one of the most widely used pigments for the manufacture of protective coatings. There are many grades, from the brilliant Indian reds, containing up to 98 per cent of Fe_2O_3, down to the natural mined brown shade oxides containing from 30 to 60 per cent of ferric oxide, the balance being silica, clay, etc. Venetian reds, consisting of about equal parts of ferric oxide and calcium sulphate, are also quite widely used. It is customary to add to iron oxide paints from 10 to 20 per cent of zinc oxide, zinc chromate, or red lead, in order to increase their inhibitive values. Such red paints are very widely used for application to tin roofs, metal siding, and general structural steel, and are to be very highly recommended for this purpose, not only for primers but also as surface coaters over red lead primers.

Black Oxide of Iron.—Precipitated black magnetic oxide of iron forms an excellent black protective paint when ground in linseed oil. Some of the natural mined black oxides of iron give similar service. The slightly basic character of the pigment accounts for its inhibitive

value. When a black paint is desired for direct application to steel, one made on such a basis will probably give very good service. These same coatings are also used to some extent as surfacers in connection with carbon and silicate pigments for use over basic primers.

Chromate Reds.—American vermilion (basic chromate of lead) gave better results in the Atlantic City tests than any other single pigment tested, having a rating of practically 100 per cent even after 4 years of exposure. Instances have, moreover, been cited where this pigment used upon iron surfaces has given protection from rust for periods greatly exceeding 10 years. In subsequent tests at Atlantic City and in Washington, this pigment gave very remarkable results, showing greater resistance to wear than any other paint tested. Unlike red lead, it does not weather to a whitish surface, being apparently unaffected by the carbon dioxide in the atmosphere. Due, however, to its relatively high cost its use has been restricted.

Carbon Surfacer Paints.—Black paints are as a rule used as a finishing coat on steel work. Carbon pigments, such as gas carbon black, oil black, natural and artificial graphite (flake and amorphous) are usually the base pigments used in these paints. Silica and other earth pigments may be combined with the carbon. The slow-drying nature of such pigments is overcome by the addition of a small amount of litharge or up to 5 or 10 per cent of red lead, a much more durable and harder film being thus obtained.

Gray Paints of Blue Lead Base.—A very valuable gray-colored rust inhibitive paint for general priming of finishing work may also be prepared from basic sulphate blue lead. The use of two parts of blue lead and one part of linseed oil containing about 5 per cent of turpentine drier makes a paint of the correct consistency. The tendency, however, of basic sulphate blue lead to fade slightly in color indicates the advisability of adding a small amount of carbon black, graphite, or similar tinting matter, and of having present a sufficient percentage of zinc oxide to prevent excessive chalking. The inhibitive value of basic sulphate blue lead is very largely due to the high lead oxide content, from 30 to 40 per cent being present.

Zinc Paints.—Zinc oxide is a strongly rust inhibitive pigment, due to its basic nature. This influence asserts itself when used in combination with lead pigments in light-tinted paints which are to some extent used for finishing coats. One of the best metal paints for general use can be made with a mixture of iron oxide and zinc oxide, the zinc oxide greatly increasing the rust-preventing properties of the paint. This type of paint is finding quite a wide application in railroad work and is giving generally good service. Zinc dust, because of its position in the electrochemical series, is an excellent protective of iron and steel surfaces, to some extent acting like galvanizing. In fact, a so-called "liquid galvanizing" has been prepared from a finely divided zinc dust composition in boiled linseed oil. Paints made with equal amounts by weight of zinc duct and zinc oxide are remarkably efficient as primers for metal surfaces.

Red Lead.—This is the most common and when made from pure materials is the most durable paint for rust protection, as shown by the Havre de Grace Bridge tests, over a period of eight years. Professor A. H. Sabin treats the subject of red lead very thoroughly in his book "Technology of Paints and Varnishes" (page 281).

The purer the red lead the denser the pigment concentration, i.e., more pigments per gal. of oil giving equal spreadability. It is now commercially possible to obtain red lead which contains 98 to 99.5 per cent Pb_3O^4. This finer pigment gives a paint that will not draw or streak and can be evenly applied.

Mr. Hallett, chairman of the committee on protective coatings of the American Society for Testing Materials writes as follows:

"If a paint is to be used which can be applied with a brush at ordinary temperatures, no better practice can be followed than the application of three coats of red lead paint. The coats should all be mixed on the same formula and should consist of No. 1 liquid red lead, paste red lead thinned with two gallons of linseed oil or dry red lead mixed at the rate of 33 lb. of pigment to one gallon of linseed oil. All of these formulas produce paint of approximately the same composition. It is well to use ⅓ boiled linseed oil and ⅔ raw linseed oil or half boiled linseed oil and half raw linseed oil for thinning the red lead paste or for mixing with the dry red lead. Either formula would be satisfactory.

"Just before the paint is applied, finely powdered litharge should be added at the rate of 2 lb. to each gallon of paint. Only the amount of paint which will be used within a short time should have the litharge added to it because after the litharge is added, the paint may thicken if it is kept for more than a day.

"For the best results, each coat should be well brushed out and an excessive length of time should be permitted between coats for the paint to dry and after the finishing coat has been applied. If possible, two weeks should be allowed between coats and after the application of the finishing coat but of course this length of time is sometimes impractical."

There is no doubt that the baking (200 deg. F.) of paints and varnishes greatly improves their durability and protective qualities.

One of the large international oil companies is having its oil lines painted two coats of red lead before dipping, finding that this gives a very good protection. The heat of the dipping greatly improves the red lead coating, which acts as a binder and affords a line of second defense in case of cracks or indentations in the asphaltum.

It must not be forgotten that in all of these tests, the surfaces were ideally prepared, the paint applied by skilled men. The reason for most paint failures in actual use lies in lack of properly prepared surface to receive the paint; poor workmanship and skill in applying it.

Varnish gives some good results when added to paints but it has not the lasting qualities out of water that good red lead has.

For under water conditions the tested plates with varnish showed up very well and Prof. Sabin concludes in his report on the tests carried out starting in 1897 at New York, Norfolk Navy Yards, and Lake Cochituate, Boston: "That the great durability of the varnish and enamel films in these tests confirms strikingly the opinion long held by the writer (Prof. Sabin) that properly made varnish films are much more impervious and resistant than any others."

Shellac Varnish in Fresh Water.—Shellac varnish is simply a solution of shellac resin, which is chemically an acid substance, in alcohol. There are many grades of shellac; the one used was what has for many years been know as "D.C." orange shellac, and it was dissolved in pure 97 per cent grain (ethylic) alcohol. Being an acid substance, it is attacked readily by the ammonia in the atmosphere. It is removed easily by soap and water. It has never been considered a durable varnish as ordinarily used on wood work, and it does not stand at all in the sea-water tests, but two years exposure under 20 ft. of fresh water does not seem to have injured it perceptibly. This may be a serious matter, for while in this regard it is no better than some other varnishes which cost less money, shellac varnish has some important and exceedingly desirable qualities which no other varnish has.

For example, occasionally we encounter the problem of repainting a large section of large water-pipe which can be spared for use only a few days. The interior of this pipe is damp. The best that can be done with it is to get out most of the visible water, but the cold surface of the metal will always be damp. No ordinary varnish will stick to such a surface, and corrosion will probably set up at once. No oleo-resinous varnish of

ordinary character, of sufficient durability to be worth putting on, will dry in the limited time at our disposal. But shellac is dissolved in a vehicle which has an intense affinity for water, and a thin film of dew will be instantly absorbed and removed by the evaporation of the slightly diluted alcohol and shellac, if applied in a thin coat, dries with the greatest rapidity. Three coats may be applied in eight to twelve hours.

There is no unpleasant odor or emanation of noxious gases, though ventilation should be secured both on account of the risk of fire and because working in an atmosphere of alcoholic vapor produces intoxication. It certainly seems from this test as though we should be justified in using shellac varnish in such a case. It is expensive, of course, and it is almost certain that the cheaper grades, which are found in ordinary use to be very much inferior in durability, would not be so efficient. In any case, it would not be necessary to use it when the conditions are such that some equally good (or better) but slower-drying coating can be used. An extraordinary showing was made at Lake Cochituate (Mass.) test in 1927 of shellac varnishes.

Bitumastic Mixtures.—There are several kinds of bituminous paints, some applied hot and others cold. Most of the cold group are diluted with volatile vehicles and often being composed of cheap resin and tars have but a poor life. The hot applications are the best coatings if properly applied, but their cost is considerable.

The Pacific Gas and Electric Company has been doing some very interesting and apparently successful work with coal gas tar, and a report on this work is given later. Many different hot coatings are on the market but the principal thing is to get a good bond between the pipe and the coating, also a coating that will stand the range of temperatures.

Emulsified Asphalts, Etc.—There are now on the market several coatings composed of emulsified asphalts, bitumen and tars, sold under various trade names. Several companies have reported their experience with this kind of protective coating on wood stave pipe as well as on steel pipe and flumes. Generally good results have been obtained. However, the records reported extend back over a relatively short period of time.

Lately there has come into the market a product known under the trade name of "Fishoilene." The name shows clearly what its basic nature is. This material has very penetrating qualities. It has been very successfully used by some large concerns. Its principal advantage is the ability of fishoil to spread and penetrate the deepest pits and pores of the surface and form an insoluble film, especially on surfaces that have been pitted by rust.

Aluminum Paint.—This subject was covered in the "Penstock Painting" report for 1928. The use of this paint is becoming more general every year.

Cements.—Concrete used as a protective coating should be a dense well-proportioned mixture. The addition of true diatomaceous earth due to the peculiar cell structure greatly increases the waterproofing qualities of the concrete. The covering should be at least three inches thick.

Concrete shot on as Gunite is a very good preservative, and requires a coating less than ⅓ the thickness of ordinary concrete due to its greater density; the sand blasting action at its application ensures a better bond than concrete. It should be carefully cured to prevent cracking.

Conclusion.—The protection of hydraulic structures by coatings is a subject that should be given careful thought in the original design, not only with the view of future maintenance cost, but that the structure may not be impaired in its usefulness by the effects of corrosion.

It calls for a coating that will withstand severe tests, and the manufacturer should be invited to give the matter more deliberate attention to the end that an economical coating might be constructed to suit these particular severe conditions.

Again attention is called to the preparation of the surface, especially for repainting. The report of the A.S.T.M. on tests says, "The preparation of old painted steel suffaces which have bare rusted spots by brush coating with benzine over and around the rust spots, burning the benzine off and then scraping and wire brushing, gives better results than scraping and wire brushing without the benzine treatment. Where any considerable amount of surface requires treatment, the comparative cost of this method and of sand blasting should be considered."

A priming coat should not be heavy and it must fill and completely wet any depressions in the metal surface and not bridge over them. Spray painting is as good as brush painting, but both require good workmanship.

Principles.—Professor Gardner, considered one of the best authorities on paints, states these principles:

(1) Basic substances in sufficient concentration inhibit the corrosion of iron. Basic pigments that are effective for this purpose are litharge, red lead, blue lead (basic lead sulphate), white lead, zinc oxide.

(2) Chromic compounds (soluble bichromates), even in great dilution, prevent the corrosion of iron. Chiromate pigments that are similarly effective when used in sufficient amount are basic lead chromate, normal lead chromate, zinc chromate.

(3) Neutral substances that do not ionize to acid reaction are considered inert. So-called neutral or inert pigments, such as iron oxide which do not excite corrosion, produce, with linseed oil, very durable films. Such pigments include black, brown, and red oxides of iron, china clay, silica, talc, and barium sulphate.

(4) Substances that form a galvanic couple with steel in the presence of moisture cause rapid corrosion. Pigments which act in this fashion (graphite, carbon black, lampblack) are used only as constituents of the finishing coats on steel surfaces, when first insulated from the metal by a coat of basic or chromate pigment paint. These carbon pigments with linseed oil form very durable and water-resisting coatings.

From the foregoing, it is apparent that paints for priming steel should preferably be made of a substantial amount of one or more basic or chromate pigments, and that these paints should be covered with water-resisting finishing coats of carbon or iron oxide paints. For instance, steel that has been primed with high-grade, red lead paint and finished with two coats of a carbon paint will be protected from corrosion under most conditions for a long period of time.

Pacific Coast Practice

Pacific Gas and Electric Company Drum No. 1 Penstock.—Inspection was made May 29, 1928, of the interior of the upper end of the pipe line between the old valve house and the forebay. The bitumastic enamel was found to be in good condition and no rusting of the pipe had taken place on the surface covered with the enamel. Considerable rusting had taken place on the rest of the surface of the pipe since the previous inspection on January 7, 1924. The amount of rust appeared greater next to the valve house than in the sections containing the first battery of air valves below the forebay.

The inspections after eleven years and fifteen years show that the paint used retarded rusting, but did not afford permanent protection from rusting.

Drum No. 2 Penstock.—Section between old butterfly-valve house and power house. Inspection of the interior made May 29, 1928, showed that the paints other than the enamel used on the inside surfaces of the pipe do not afford protection to the steel. Both of the enamels used sagged considerably at the top of the pipe, but left no holidays and no rusting occurred since the painting was done, about three years previously. Rusting showed on all of the test surfaces painted. The

outside coating of red lead was in good condition. The outside coating of enamels showed some alligatoring and a tendency to peel off. Both kinds of enamel were applied under very unfavorable weather conditions, there being snow on the ground at the time.

Wise Penstock.—Inspection of the interior April 21, 1927, after three years and ten months of service since last painted, showed the section near the upper end of the line close to the Venturi meter badly rusted. There were barnacles all over the surface about ⅛ in. high. Only one coat of red lead had been applied at this particular location in the pipe and the surface was not thoroughly cleaned before spraying.

On account of being generally successful in using bituminous paints for interior pipe painting and noting the excellent results obtained by the U. S. Bureau of Reclamation with the use of water and coal gas tars for similar work, and having the tar on hand, it was decided to cover most of the interior of the Spaulding 3 penstock with tar paints.

The Bureau of Reclamation has adopted as standard for tar paint the following specifications for metal work: "All metal work shall be thoroughly cleaned of all loose scale and given one coat of water gas tar followed by two coats of coal gas tar. All coats shall be applied when the temperature of the air and of the metal is not less than 60 deg. F. The water gas tar shall have a specific gravity of not less than 1.05 or more than 1.10 to 60 deg. F. and shall be of such a consistency that it can be applied with brushes. The melting point of the coal gas tar, as determined by the cube method, shall lie between 105 and 110 deg F. Both the water gas tar and the coal gas tar shall be freed from moisture and all fats shall be extracted from the water gas tar.

If the water gas tar is too thick to spread, the manufacturer may use suitable light oil, satisfactory to the engineer, for thinning. The water gas tar may be applied without heating, but the first coat of coal gas tar which may be applied a few hours after the application of the water gas tar, shall be applied hot and brushed out as thin as possible so that the coating will not run or peel after it is dry. The second coat of coal gas tar shall not be applied until after the first coat has set. The manufacturer may use water gas tar without the fats extracted, in which case the first coat of coal gas tar shall not be applied until the former has set, which will require usually at least four days. This tar paint will be well worked into all joints and open spaces."

Some experiments were made with water and coal gas tars as specified by the Reclamation Bureau as well as with coal gas tars with melting points up to 150 deg. F. and with Biturine enamel, for comparisons. Tests were made of the paints, which had been brushed on thin metal plates, in cold storage rooms with the temperature as low as 0 deg. F. and in ovens as high as 125 deg. F. It was decided from the results obtained to use the water gas tar as specified by the Bureau of Reclamation, because it clung to the metal under all conditions, and to use coal gas tar with a melting point of 133 deg. F. The interior surface of some of the sections in the line was covered with the regular Biturine solution and Biturine enamel so that a direct comparison of the paints could be made. The inside of the pipe was sand blasted before the paints were applied. The greater part of the sand blasting and painting was done before the pipe was installed. The priming coats were brushed on because it was felt by those in the field that a better job was being done by this means. The enamel and the coal gas tar were applied hot, using daubers.

The use of an electrically heated kettle with thermostatic control and electrically heated paint buckets materially helped in the application of the hot tar by keeping it hot in the paint bucket, which made it easier to spread and gave a much better job. The heat in the kettle was under perfect control and the services of one man were done away with. A temperature of 300 deg. F. was maintained in the kettle. Thermometer readings showed that the pipes reached a temperature of 140 deg. F. during three to four hours of the day at the time the painting was being done. Both the enamel and the coal gas tar sagged from the tops of the first few sections painted. The sagging was caused mainly by the weight of the material. The thinner coat made possible by the use of the electric paint buckets practically eliminated the trouble. The Biturine enamel upon sagging seemed to split the primer coat. The coal gas tar did not leave the primer but merely moved down without peeling or leaving any holidays.

It is planned to paint the inside of one section of this line with coal gas tar thinned down with still bottoms. The thin tar will be sprayed on cold. Thus it will be known at the time of some future inspection if the coal gas tar can be applied cold instead of hot.

For experimental purposes also, it is expected to paint the inside and outside of one section of the pipe with an aluminum paint made by floating flaked aluminum in water gas tar. An adjacent section will be painted inside with Bitulumin paint. The entire outside surface of the pipe, except the one mentioned above, will be painted with Bitulumin, used to keep the temperature inside down, in case the pipe is drained in the summer, and because of the success had with this particular paint on similar structures. The outside surface will be cleaned with wire brushes before the paint is applied. The cost of the tar paints is a little more than one-fourth the cost of the Biturine solution and enamel.

San Joaquin Light & Power Corporation — Browns Creek Ditch—The entire ditch was rebuilt in 1923. The plates in the metal flumes are of No. 14 gage copper bearing steel, riveted together with No. 8 soft steel rivets. The plate was given a shop coat inside and outside of red lead and oil. After the first season's runoff, all flumes were given one coat of Biturine solution on the bottom one-third and one coat of Biturine enamel on the bottom one-fourth of the inside perimeter or where the metal showed wear from erosion. After five years of use these flumes show very little corrosion but due to the presence at times of sand in the water the paint on the bottom is eroding. It is believed that Biturine enamel gives a very efficient covering to resist erosion while the solution resists rusting and corrosion well.

Ditch No. 2—Crane Valley System.—Two metal flumes were rebuilt in 1926. The flume section is 8 ft. in diameter with 8 in. tangents and the plates are No. 14 gage copper bearing steel, with riveted joints, No. 7 soft steel rivets being used. No shop coat of paint was applied but after removing all rust and loose scale a field coat of Biturine solution was applied inside and outside and on all rods, nuts and washers. On account of the small clearance between the stringers and side of flume material, a coat of the solution was applied to the outside surface of each tangent end of plate before erection. The Biturine enamel was applied on the bottom of the inside surface of the flume to a height of about 16 in. above the invert; the enamel was also applied to the riveted joints on a strip about 5 in. wide.

Two other flumes in this ditch were repaired in 1923 by installing new metal flumes on the old timber bents. No. 14 gage copper bearing steel was used and the flumes were painted similarly to those described in the paragraph above.

Ditch No. 3.—In 1923, Ditch No. 3 was reconstructed. This involved the rebuilding of two flumes. No. 14 gage copper bearing metal riveted together with No. 8 soft steel rivets was used. The plates were given a shop coat of red lead and oil inside and outside, except for the joints where they were left unpainted for a distance of 2.5 in. from the punched edge. In the field, one flume was given an inside coat of Biturine solution which was followed by a coat of Biturine en-

amel on the lower one-third of the perimeter. One coat of asphaltum varnish was used on the outside.

Based upon experience of the past five or six years, the construction department of this company specifies the use of Biturine solution applied to the inside and outside surfaces of all new flumes, and Biturine enamel on the inside surface on the lower one-third of the perimeter. When new flumes are raised to increase their capacity, all new metal is given a coat of Biturine solution and the flume is repainted inside with the solution at all points that show wear. If necessary, Biturine enamel is applied on the bottom of the flume, as stated above. Biturine solution and enamel are applied with brushes; the solution is applied cold, and the enamel hot. In general, a shop coat of paint is not specified.

The operating department uses Biturine solution and enamel on metal flumes when they require repainting.

Balch Power Plant—Paint—The following specifications were used for the Balch power plant, completed early in 1927:

"All exposed structural steel below the main floor level shall be given two coats of Biturine No. 5 solution. The I-beams above the tail race shall be given one coat of Biturine enamel in addition to the two coats of solution.

"The following items shall be given two coats of Biturine solution:

Oil storage tanks
Wheel pit liners
Pressure regulator
Wheel pit shutters
Air duct louvres
Wheel pit baffles
Beams under the temporary end of building
Energy absorber in wheel pit
Under side of floor plates
Curb angles
All exposed piping and machinery under the floor level
Columns in basement.

"The wheel-pit liners and all louvres shall be given one coat of the Biturine enamel in addition to the two coats of Biturine solution. Enamel should be applied to all surfaces which, in the judgment of the field engineer, are subject to severe exposure or wear."

The pipe manifold at head of penstock, steel tunnel adit closures, and the ungalvanized steel members of the intake and trash-rack structure were given two coats of the solution, and in case of severe exposure to wear or corrosion, a coat of the enamel as well.

Los Angeles Bureau of Power and Light—Regarding the application of protective paint on the fifth unit penstock at San Francisquito power plant No. 1, the following is a summary of the types of paints used and their various locations:

The penstock is made up of one main line of exposed pipe and two branches of buried pipe.

The exposed pipe consists of 1,300 ft. of double butt-riveted pipe, varying from ⅜ x 84 in. to 9/16 x 84 in., and made up of alternate two and three-course sections, 16 ft. 8 in. and 26 ft. long respectively; and 800 ft. of welded pipe, varying from 11/16 x 84 in. to 1.25 x 80 in., and consisting of 20- and 30-ft. sections.

The two buried lines are of welded pipe, varying from ⅞ x 57 in. to 1⅛ x 54 in., and made up of 30-ft. sections.

The interior surface treatment is divided as follows:

16,000 sq.ft. of Krodeproof on riveted pipe.
14,000 sq.ft. of Thorkote on riveted pipe.
2,000 sq.ft. of Thorkote on welded pipe.
16,000 sq.ft. of Biturine enamel on welded pipe.

The interior surface of the east branch is painted with Krodeproof, while the west branch is painted with Thorkote. Each of these has an area of 16,000 sq.ft. The exposed area of the main line is divided between Detroit graphite, Biturine enamel and Valdura, each having approximately 11,000 sq.ft. of riveted and 5,000 sq.ft. of welded pipe. The 32,000 sq.ft. of outer surface of the two branches are coated with Petrolastic.

The Valdura was sprayed in two coats of 400 sq.ft. per gal. per coat, using 10 per cent distillate to facilitate spraying. The Detroit graphite was No. 501 red primer for the first coat, and was sprayed at 400 sq.ft. per gal., and No. 30, for the second coat, sprayed at 500 sq.ft. per gal. The Biturine enamel consisted of one primer coat of Biturine solution, sprayed at 500 sq.ft. per gal., and one coat of No. 7030, sprayed at 750 sq.ft. per gal. Parts of the Biturine and Detroit graphite were hand-brushed, where the penstock was in a tunnel. This was done as the fumes were objectionable when sprayed. Thorkote, which is water emulsified asphalt, was sprayed in two coats at 120 sq.ft. per gal. Krodeproof, which also is water-emulsified asphalt, was sprayed in two coats of 80 sq.ft. per coat. The Petrolastic XXasphaltum was the only hot-applied coating. This was applied at 750 sq.ft. per bbl. over a sprayed coat of Mathews "Any Roof Black" asphalt paint, thinning 50 per cent with distillate.

Results of Questionnaire

In response to a questionnaire on protective coatings, eleven answers were received from three companies. The most important items have been extracted from the questionnaire and are as follows:

A steel pipe line painted with two coats of graphite paint, applied with brush, has given excellent results during nearly eight years of service. Temperatures range from freezing to 125 deg. F.

One pipe line was reported in which a coat of red lead-graphite was applied inside and outside in shop. In the field a second coat of red-lead graphite was applied on the inside, and one coat of Oronite applied outside. This job has been satisfactory during eight years of service.

Biturine enamel, applied four years ago on the inside surface of a galvanized metal flume, has given very good service for four years. Some failure has been noted at joints, due in part to the movement of plates where the flume is built on a curve. It was reported that no maintenance work has been done on this job.

Four examples of the use of Krodeproof were given. Two wood-stave pipes painted on the exterior surface three years ago, have given good results. Application by air-gun gave better results than by using hand brushes. After nearly two years of service, the Krodeproof coating applied on the inside surface of a steel flume is apparently as good as new. This flume was put in service for one year without any paint, which allowed the metal to scour and give a highly receptive surface free from grease, oil and other substances.

Experiments are being made with Inertol under similar conditions. The fourth example of the use of Krodeproof is on the trash-racks of an intake structure. Maximum temperature 105 deg. F., minimum 10 deg. F. The surface was wire-brushed before applying the paint. It had been given a shop coat of red lead. After three years of service, some checking has been observed, and this is attributed to the application of the coating in too cold weather. The old work was very rusty and pitted.

The use of coal-gas tar was reported on two galvanized steel flumes. Temperatures at locations vary from 6 deg. F. to 95 deg. F. The surface was cleaned with gasoline and wiped just before applying the tar. A priming coat of water-gas tar was brushed on; the other coats were brushed on hot, using "Tampico" daubers. Water-gas tar of specific gravity between 1.05 and 1.10 at 60 deg. F., was used. The melting point of the coal-gas tar was between 105 deg. F.-110 deg. F. This proved to be too low and was later changed to 130 deg. F. or 135 deg. F. Some running at bottom of flume has been noted. Under warmer temperature conditions, it is thought the tar sticks better. Too thick coatings may help to cause running. The

sheet should be warm before applying hot tar as it chills and does not stick well otherwise. These jobs are less than one year old.

The successful use of "Rustkilla" was reported on the exterior of a steel penstock. After nearly seven years of service the condition of coating is good. The coating was applied by brushing on a surface previously cleaned by means of steel brushes.

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Standard Specifications for Bone Black.

Standard Specifications for Orange Shellac.

Tentative Specifications for Aluminum Powder for Paints.

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Standard Specification No. 20 for Liquid Paint Drier.

Specification No. 18b for Varnish Spar, Water-Resisting.

Specification No. 376 for Varnish, Shellac.

Specification No. 19 for Asphalt Varnish.

METER COMMITTEE REPORTS[2]

Former reports of this committee have served as an exchange of ideas whereby maintenance costs might be lowered and service improved through adequate records on the various pieces of apparatus whose satisfactory operation was dependent upon some timing device.

The following report as prepared by F. G. Philo, superintendent of steam generation of the Southern California Edison Company, discloses the study which is being devoted to this interesting and important subject.

Speed-Time—A Method of Time Control*

INTRODUCTION of electric motor-driven clocks in the United States made necessary more accurate frequency regulation by the power companies of the country. Prior, however, to the introduction of electric clocks in Southern California, the Southern California Edison Company began experiments with equipment for automatically controlling system frequency. The first home-made apparatus was set up in Long Beach No. 2 steam plant in the fall of 1927. This apparatus demonstrated the possibility of automatically regulating system frequency and maintaining more accurate speed-time than could be hoped for by hand regulation.

The equipment now in use at the Long Beach steam plants for automatic maintenance of constant frequency and consequently accurate speed-time, comprise an automatic frequency controller, a master clock and a short-wave receiving set. Contacts closed in the automatic frequency controller send impulses through suitable relays to the governor motor causing the motor to change the tension of the governor auxiliary spring. The master clock compares speed-time as indicated by a hand, driven by a Telechron motor and pendulum-time indicated by a hand, driven by a pendulum clock. The accuracy of the pendulum clock is checked twice each day with Bureau of Standards time as indicated by short-wave radio time signals broadcast by the Naval Radio Station at Arlington, Virginia.

Contacts in the automatic frequency controller are so constructed that the duration of the impulses will increase proportionately with the departure of the actual frequency from the desired frequency. A variable resistance is provided in the measuring circuit of the controller by means of which the action of the controller can be biased to hold the frequency high or low as desired to correct cumulative errors in speed-time.

The synchronous motor of the master clock is connected through instrument transformers to the station bus, this being the most dependable connection

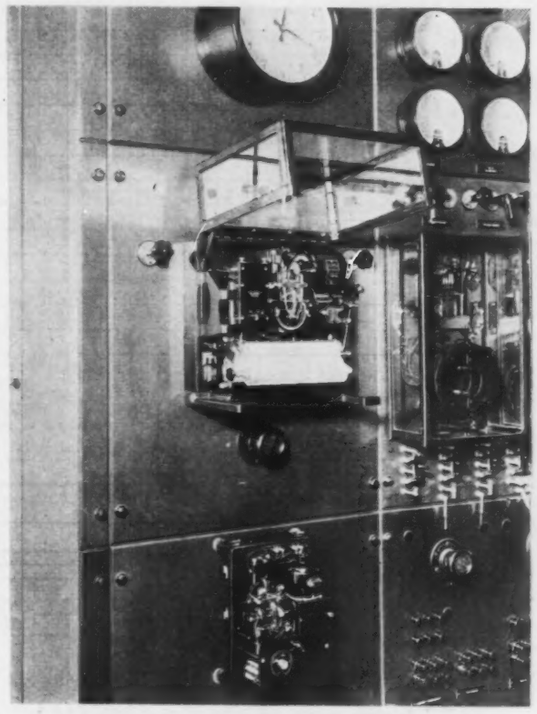


Fig. 1. Frequency meter and frequency controller on switchboard at Long Beach No. 3 steam plant.

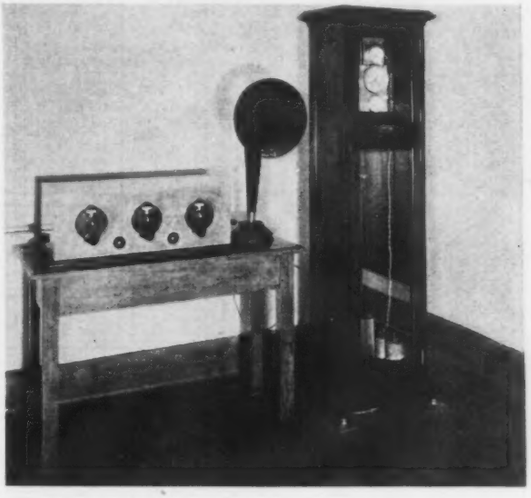


Fig. 2. Master clock and short-wave radio receiving set in use at Long Beach No. 3 steam plant.

[2] **L. L. Conrad,** Southern California Edison Company, chairman. **J. C. Abel,** Pacific Gas & Electric Company, vice-chairman. **Coast Counties Gas & Electric Company:** W. R. Van Bokkelen. **General Electric Company:** Fred Garrison, W. C. Smith. **Great Western Power Company of California:** W. Knight. **Duncan Electric Manufacturing Company:** A. F. Blecksmith. **Los Angeles Bureau of Power & Light:** J. C. Albert, L. H. Ellerman. **Los Angeles Gas & Electric Corporation:** W. A. McMeekin. **Midland Counties Public Service Corporation:** D. D. Smalley. **Leeds & Northrup Company:** L. E. Emerich. **Pacific Gas & Electric Company:** L. D. Tycer, W. N. Lindblad, N. P. Carlson, Jr., G. H. Searle, R. Crowell, E. L. Hughes, O. A. Knopp. **Sangamo Electric Company:** J. G. Monahan, L. A. Nott. **Schweitzer & Conrad, Inc.:** H. M. Thomas. **San Joaquin Light & Power Corporation:** G. A. Collins, C. F. Gilcrest. **Southern California Edison Company:** E. Ealson, J. H. Dorsey, L. H. Beebe, W. R. Frampton, J. H. Vivian. **The Southern Sierras Power Company:** R. G. Jones. **San Diego Consolidated Gas & Electric Company:** W. H. Talbott. **Westinghouse Electric & Manufacturing Company:** J. E. Bridges, W. F. Grimes. **Weston Electric Instrument Corporation:** A. A. Barbera, J. H. Southard.

* Report of clocks and timing devices subcommittee of meter committee, Engineering Section. F. A. Redding, chairman.

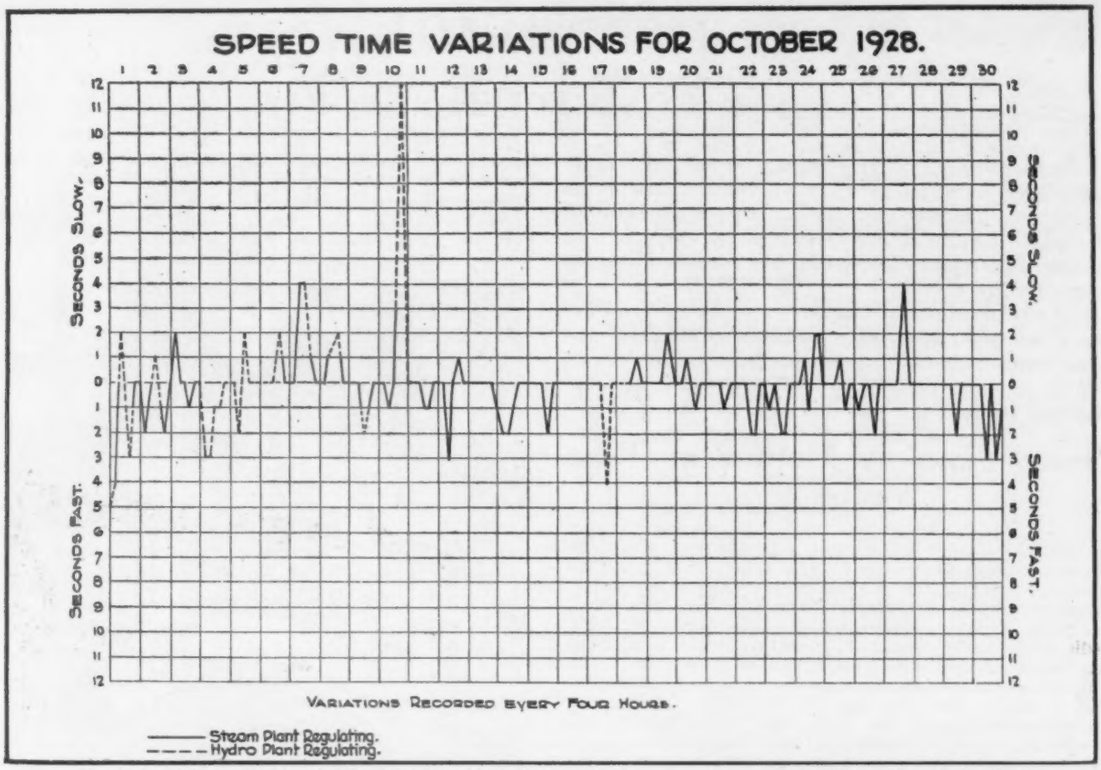


Fig. 3. Speed-time curve for month of October, 1928, showing four-hour comparisons of speed-time and pendulum-time.

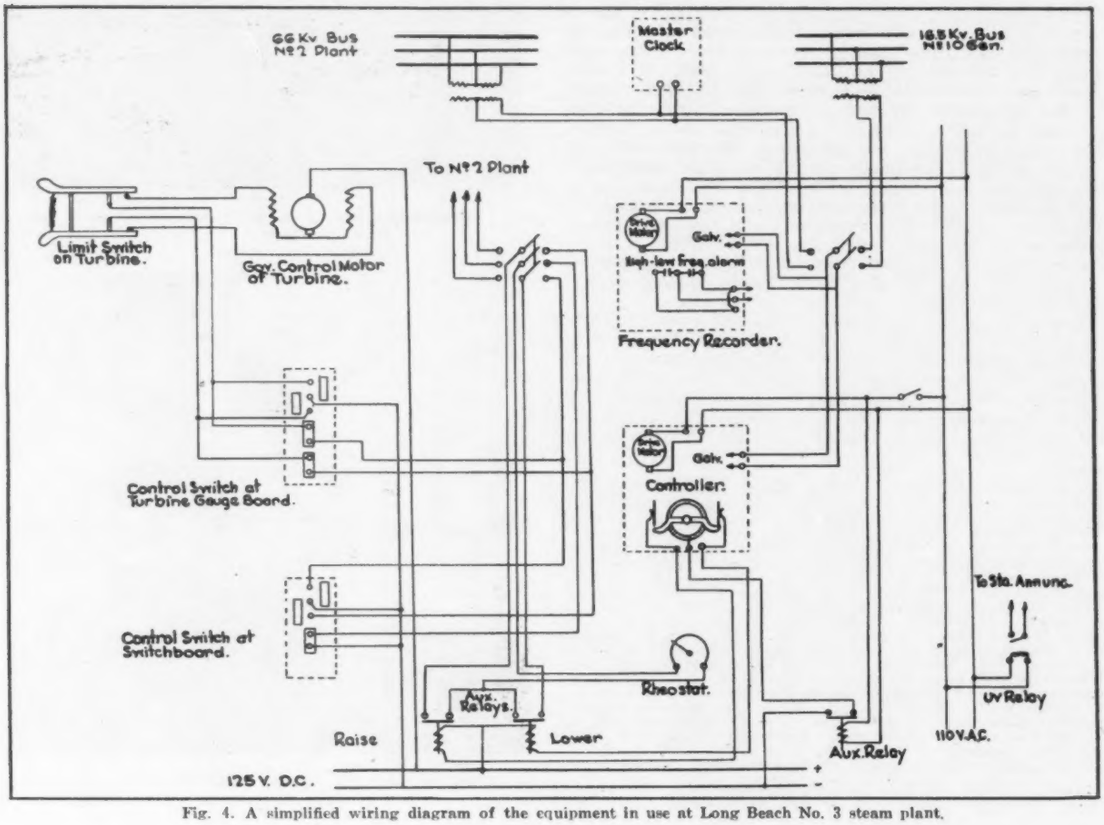


Fig. 4. A simplified wiring diagram of the equipment in use at Long Beach No. 3 steam plant.

to the system available. The relation of speed-time to pendulum-time as shown on the master clock is observed every hour and noted in the log book and the controller bias changed immediately, if necessary, to correct any error. In this way the error in speed-time due to high or low frequency is kept within close limits. When it is necessary to change the controller bias to correct speed-time, only a sufficient amount of resistance is introduced to effect the desired change over a period of one or more hours. In this way the change in speed-time is very slight, normally being less than one second per hour.

When the time signal is received on the radio receiving set a stop-watch is started. This watch then is stopped when the pendulum-driven hand of the master clock is on the even minute. The error, fast or slow, then can be noted easily by the position of the locked hand of the stop-watch. The stop-watch method has been found to be convenient and more accurate than any method of direct comparison. With a high-grade pendulum clock such as that used in the master clocks it is possible to keep pendulum-time accurate for indefinite periods provided the clock can be protected from vibration and magnetic influence.

On the Edison system the regulation of frequency is transferred back and forth between the Big Creek hydro plants and the Long Beach steam plants, 280 miles apart. A master clock in each of the regulating stations and in the central dispatcher's office at Alhambra are necessary. To avoid confusion which might result from attempts to check all of these master clocks directly by means of radio time signals taken independently at the different stations, only the master clock at Long Beach is checked with the radio time signals. The other master clocks are compared every four hours with the Long Beach clock by signals transmitted by telephone and corrected to agree with the Long Beach clock. By this method the Long Beach steam plants are responsible for the accuracy of the speed-time maintained by the Southern California Edison system. Again the stop-watch method is used in comparing master clocks at Big Creek and Alhambra with Long Beach.

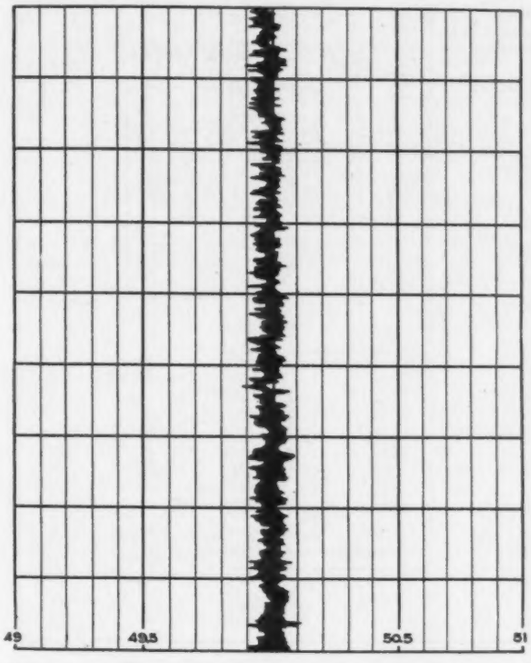


Fig. 5. A sample section of chart from frequency recorder showing typical automatic frequency regulation.

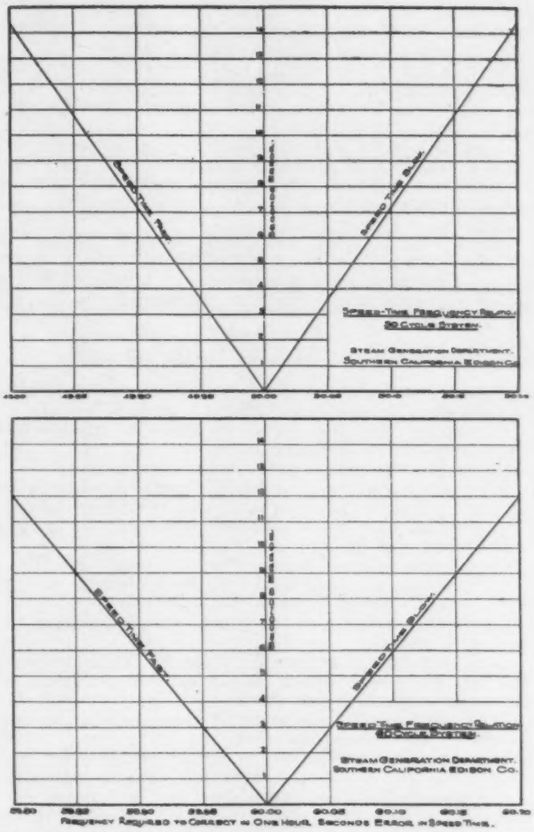


Fig. 6. Speed-time frequency relation for 50 cycles (above) and for 60 cycles (below).

Development work is being continued at Long Beach steam plant for the purpose of perfecting methods and apparatus for keeping correct speed-time and making the regulation entirely automatic. It is proposed to install in the near future a master recording clock in place of the indicating clock now in use. This recording clock will make a continuous record of speed-time and show any cumulative error and will be provided with contacts which will be used automatically to bias the frequency controller to correct cumulative errors in speed-time.

It is hoped that the study being given the problem of automatic frequency regulation and accurate speed-time at Long Beach steam plant and by other departments will develop other simplifications of apparatus and methods for maintaining accurate speed-time.

Testing High-Voltage Metering Installations

By O. A. KNOPP*

A summary of the procedure followed by operating companies in testing high-voltage metering installations is given in this report.

BECAUSE of the expense and difficulties in making tests on metering equipment for voltages above 11 kv. many companies have refrained from making complete tests including all the various elements which

* Report prepared for meter committee, Engineering Section.

have a bearing upon the accuracy of the metering installation, such as the current transformers, potential transformers, wiring connections and meter.

This report is intended to present a summary of the methods practiced by the member companies to serve as a guide to those companies that so far have only made partial tests.

A questionnaire was sent to ten correspondent members of the P.C.E.A. meter committee and nine answers were received. One questionnaire was sent to the chairman of the N.E.L.A. meter committee and an answer was received.

One of the member companies reported that it has no high-voltage metering installations. The answers of the remaining nine companies are tabulated in the following table, where the nine companies are denoted by numerals, 1 to 9.

Tabulation of Answers to Questionnaire

Companies testing meters, current and potential transformers before installation—1, 2, 3, 4, 6 and 7.

Companies making tests on current transformer and meter before installation—9.

Companies making overall installation tests—2 and 3.

Companies making installation tests separately on current, potential transformers and meters—4 and 8.

Companies making installation tests only on meters —3, 5, 6, 7 and 9.

Companies making periodic overall tests—2.

Companies making periodic tests separately on current, potential transformers and meters—4.

Companies making routine tests on meters only—1, 3, 5, 6, 7 and 9.

Companies making periodic tests in the laboratory, five to ten years apart, to determine accuracy of instrument transformers—7.

From the above tabulation it appears that a majority of the companies test the instrument transformers before installation, in the laboratory, for connection to the meter and test only the meter after installation. This procedure does not guarantee correctness at all times and errors in the registration may exist for years in important metering installations. Several member companies have found it advisable to make overall installation tests and periodic tests as a part of their routine, to avoid the possibility of large losses.

The New York Edison Company does not make periodic overall tests, but assures itself of the accuracy of the metering installation once a year by testing the wiring and current transformers, using line power. This method, which is described in N.E.L.A. Serial Report No. 278-31, no doubt can be recommended highly to all those companies now making only secondary tests and that want additional insurance against possible losses but hesitate to go to the greater expense of overall testing.

Totalizing Demand on Metered Circuits*

A laboratory investigation of demand metering using a combination of relays and meters. Readings of the demand meter are in abritrary units and the actual demand is obtained by multiplying these readings by the proper kilowatt constant.

SOMETIMES it is desirable and necessary to measure and totalize the demand on two or more metered circuits. In order to accomplish this on two circuits feeding one of its consumers, the Southern California Edison Company has chosen a type DT two-circuit totalizing relay and a PD demand meter. The circuits are metered on the 4-kv. side of the Y-connected transformer banks. Metering equipment for each circuit consists of three 1500/5 current transformers, two 20/1 potential transformers and two two-element polyphase meters. This method of metering

* Report prepared for special metering subcommittee of meter committee, Engineering Section. J. H. Dorsey, chairman.

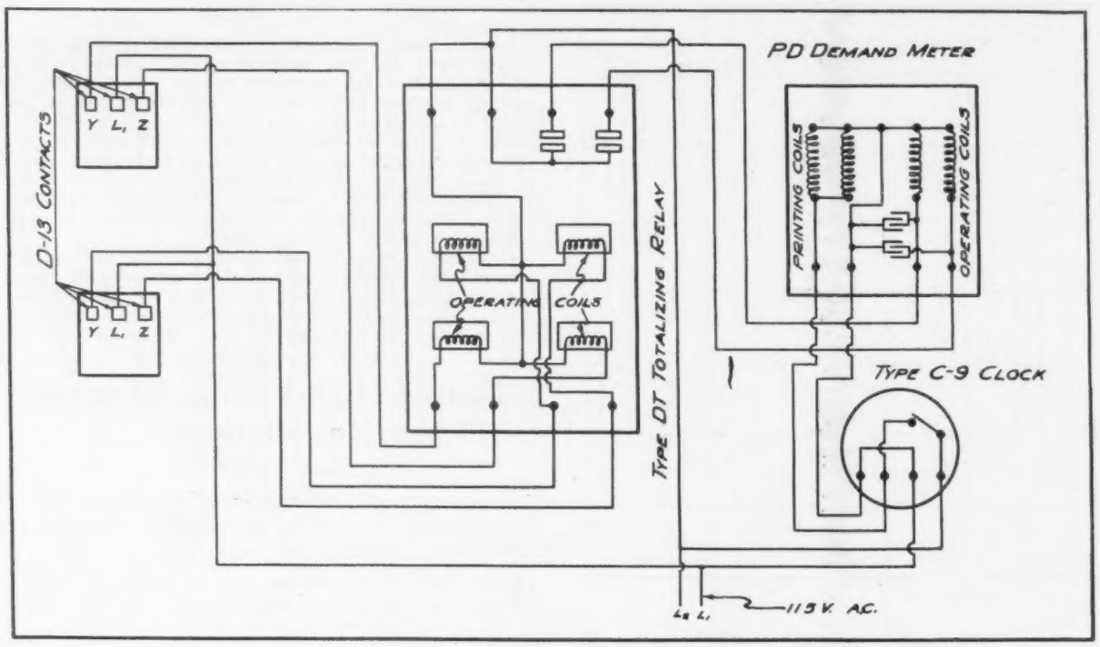


Fig. 1. Connection for type PD demand meter, C-9 clock and type DT two-circuit totalizing relay to measure demand on two metered circuits.

three-phase four-wire circuits with three-current transformers and two potential transformers has been fully discussed at previous meetings and hence will not be covered again.

The control circuit diagram for the DT relay and PD demand meter is found in Fig. 1. Each polyphase watt-hour meter is equipped with type D-13 contacts. To install these contacts it is necessary to remove the old watt-hour meter disc shaft and install a shaft that has two worms, one for the register and one other for the contact mechanism. The contact assembly consists of five-point cams mounted on a common shaft. These two cams are staggered with respect to each other so that the points of one will alternate with the points of the other in transmitting impulses to the DT relay. A contact is made and an impulse transmitted to the DT for every 2.5 revolutions of the watt-hour meter discs. In terms of watt-hours the value of a single contact is 2.5 times the disc constant which, for this installation, is $2.5 \times 0.6 \times 300 \times 20 = 9{,}000$ watt-hours or 9 kw.-hr.

The DT relay totalizes the impulses sent out by the watt-hour meters. Each impulse operates a solenoid which advances a crown wheel in a differential mechanism an amount equivalent to one impulse. These two crown wheels (one for each circuit) advance the ring gear an amount equivalent to the summation of the rotations of the crown wheels. The ring gear is geared to the shaft that transmits the impulses to the demand meter. By a special design in this gearing the impulses delivered to the demand meter are spaced apart in time, although several of them may have been received simultaneously from the D-13 contacts on the watt-hour meters. This lagging gives the receiving DP demand meter time to operate.

For every two impulses received by the two-circuit totalizing relay one is transmitted to the demand meter and for this reason it has a constant of 2. These impulses received by the demand meter operate a set of solenoids which advances a wheel whose circumference carries raised, evenly spaced, numbers running consecutively from 00 to 99 inclusive. Each impulse advances this wheel one number. These numbers pass under the ink ribbon and record tape. At the end of the demand interval (15 minutes in this installation) the C-9 clock closes the circuit that energizes the printing coils which stamp the record tape with the number that is under it at that instant. The wheel then resets to zero, the tape advances and all is ready for the next interval. Each time 99 passes under the record tape a second wheel carrying the hundreds is advanced. The record tape rolls come stamped with the hours of the day, a.m. and p.m.

These readings printed on the record tape are in arbitrary units, giving only the number of impulses received during any particular interval. The demand is obtained by multiplying this number by the proper kilowatt constant.

$$\text{Kilowatt constant} = \frac{KXR}{1000 \times N \times I} \text{ where}$$

K = watt-hours per revolution of disc,

R = revolution of watt-hour meter disc per revolution of contact cam shaft,

N = number of teeth or points on cam, and

I = time interval of demand expressed in hours.

For this problem the values are:

K = 3,600 $(0.6 \times 300 \times 20)$,

R = 25,

N = 5,

I = ¼, and

Kilowatt constant = 72.

The kilowatt constant is easily derived by thinking in terms of impulse value. It has been pointed out that the value of each impulse received by the totalizing relay is 9 kw.-hr. This multiplied by the relay constant and the result divided by the time interval expressed in hours will give the kilowatt constant

$$= \frac{9 \times 2}{0.25} = 72.$$

Cyclometers mounted on the relay and demand meters register the impulses transmitted and received, by the two instruments. These counters serve as a check on the demand meter. The total impulses registered by the counter during a certain interval multiplied by the kw.-hr. constant should equal the kw.-hr.

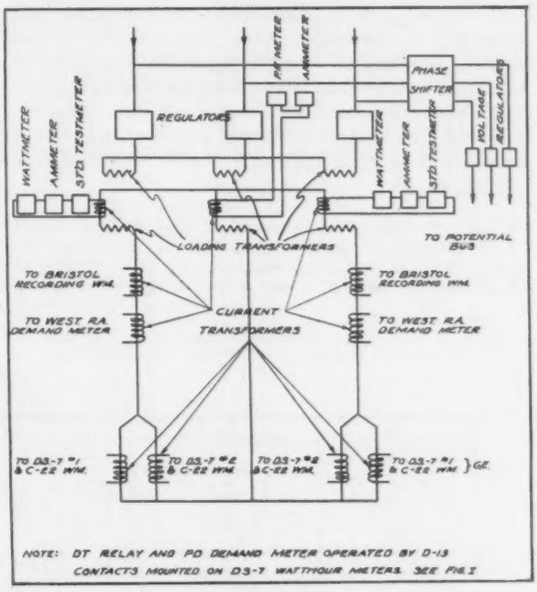


Fig. 2. Connection for tests on DT relay, PD demand meter, and C-22 totalizing wattmeter.

registered by the watt-hour meters during the same interval. The kw.-hr. constant equals the kw.-hr. constant times the time interval expressed in hours or fractions thereof. For example, let each watt-hour meter make 25 revolutions in a certain interval. Then

$$\frac{25 \times 2 \times 3600}{1000} = 180 \text{ kw.-hr.}$$

Also, 25 revolutions on each watt-hour meter should register 10 impulses on the demand meter. Then

$$10 \times 72 \times \tfrac{1}{4} = 180 \text{ kw.-hr.}$$

The foregoing equipment was tested in the standardizing laboratory by setting up a three-phase circuit. In this circuit were installed two single-phase rotating standards and a three-phase recording wattmeter. Off of this circuit were fed two parallel circuits, each of which was metered by one of the D-13 contact-equipped watt-hour meters. The demand equipment was connected as shown in Fig. 1.

Fifteen-minute runs were taken and the demand meter checked against the total demand calculated from revolutions made by the watt-hour meters. These results in turn were compared with those obtained

from the rotating test meters and wattmeter. The average error of the demand meter did not exceed 1 per cent. The meter was checked at various loads. After making these above tests with normal voltage (115 a.c.) on the demand control circuit similar tests were made with abnormal voltages of 90 and 125 volts on the control circuit. Neither voltage caused faulty operation.

After permanent installation in the field an overall test will be made. With the above demand equipment it is necessary that each circuit have the same current and potential transformer ratios.

Metering 132-Kv. Circuits*

The metering equipment described consists of two three-element watt-hour meters, two curve-drawing wattmeters, three current transformers and three potential transformers. An over-all three-phase test was made in the standardizing laboratory upon metering equipment before it was installed in the field. The spare metering potential transformer was certified by the Bureau of Standards at Washington, D. C.

THIS metering equipment is installed at Harbor substation of the Southern California Edison Company. The power bank consists of four 20,000 kva. transformers, one of these being a spare. The bank is delta-connected on the primary side and star-connected on the secondary side and fed at 66 kv. Phase voltage on the secondary side is 132 kv.

The metering equipment is in the star-side of the power bank and consists of the following equipment: two type H 3-element watt-hour meters, two type C-7 2-element curve-drawing wattmeters with 10-amp. current coils, three type KB 300/5 current transformers, and three type E 116Y-66000-77000-88000/110-volt metering potential transformers and one type R wattmeter; the latter being the transmitter of the remote indicating equipment for the consumer. Spare equipment consists of one potential transformer and four current transformers. Transformer and meter connections are shown in Fig. 1.

Before the field installation was made the aforementioned equipment was given an overall test in the standardizing laboratory. One of the metering potential transformers was routed through the Bureau of Standards at Washington, D.C., for certification at various voltages and secondary burdens, one of which was a potential-transformer test set. However, due to the delayed delivery of the certified transformer it was necessary to make the field installation prior to the determination of the ratio and phase-angle errors of the metering transformers. The Bureau of Standards certificate of accuracy for the standard transformer tends to indicate that small errors may be expected when these tests are conducted during the next semi-annual field test. All current transformers were tested for ratio and phase angle with a special testing set.

After equipping the watt-hour meter registers with ratchet attachments to prevent reverse registration the meters were lagged and balanced using a single-phase source as shown in Fig. 2.

* Report prepared for special metering subcommittee of meter committee, Engineering Section. J. H. Dorsey, chairman.

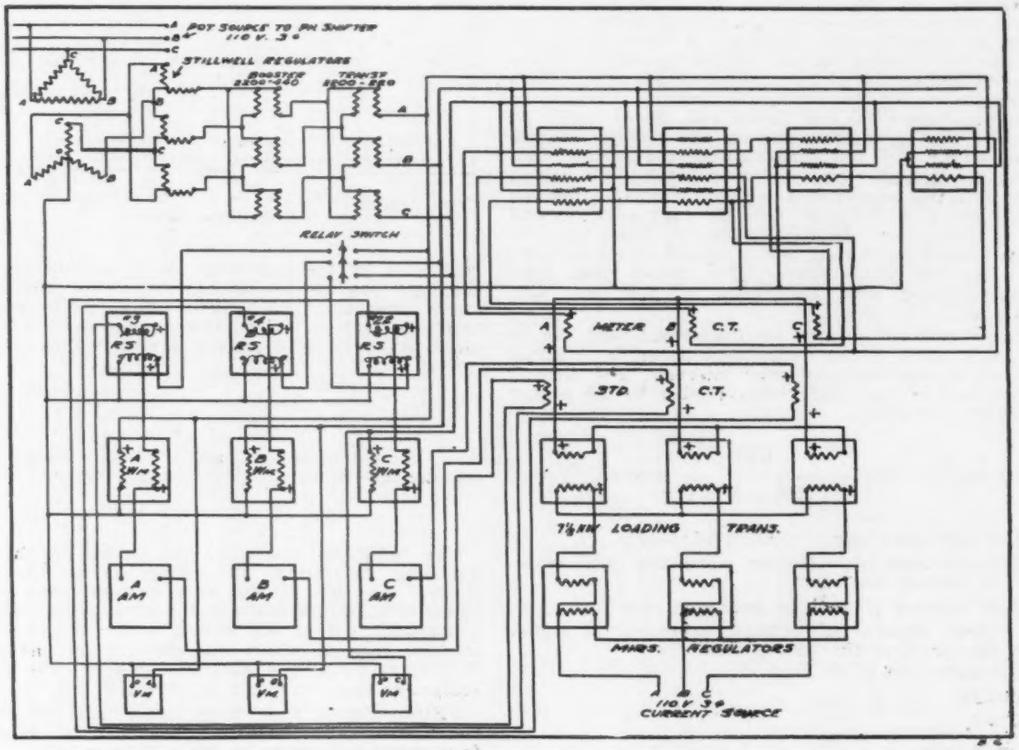


Fig. 1. Connections at Harbor substation for three-phase, three-element meter test connections.

Figure 3 gives the diagram of connections for testing the watt-hour meters using a three-phase source. Curves were run at 100, 50, and 10 per cent loads, 0.80 lagging power factor with and without the curve-drawing wattmeters in the circuit. It was found that the curve-drawing wattmeters had no effect upon the accuracy of the watthour meters. Similar tests with like results were made with and without the neutrals of the current and potential sources tied together. In the field it was found that the large volt-ampere burden of the curve-drawing wattmeters caused no unbalance of voltages at the watt-hour meters.

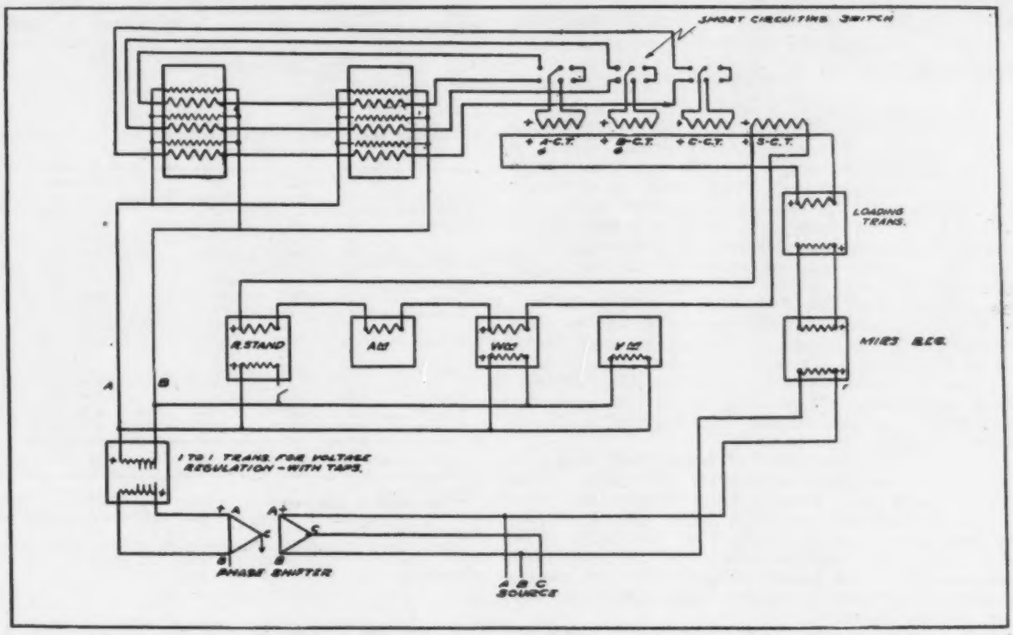


Fig. 2. Diagram of connections for single-phase element balance on three-phase, three-element meters for Harbor substation.

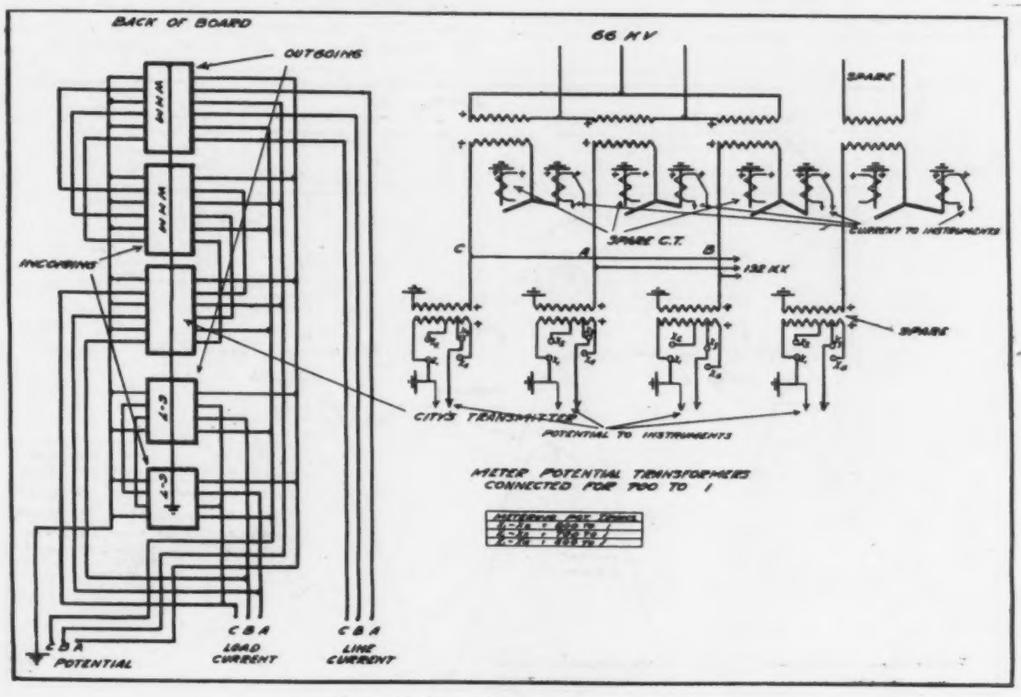


Fig. 3. Harbor substation meter connections.

Wave Form as it Affects Watthour Meter Accuracy*

An investigation of wave forms for the purpose of determining the effect upon the accuracy of induction test meters energized on circuits controlled by various combinations of devices commonly used in testing meters.

TO determine the effect of poor wave form upon the accuracy of a test meter various means of acquiring the current supply for the test meter were used and a series of tests were made at different power factors with the idea of comparing the energy measured by a test meter with the power through an indicating wattmeter over a definite time interval. The current wave form was observed by means of an oscillograph and oscillograms were taken.

Cases 1 to 6 inclusive (see Figs. 1 to 6 inclusive), show the wave form as found to be similar in each condition as may be noted in the oscillograms reproduced in Figs. 1-2, 3-4, and 5-6. It was decided then to produce as bad a wave form as possible. Several methods were tried, such as using the current produced from exciting various station-type loading, distribution and auto-transformers.

One method used was that of taking two banks of transformers connected delta-star, star-delta. The delta-star bank was excited three phase and connected to it was the star-delta bank with a single-phase load placed across one coil of the delta. The neutrals were joined and the unbalanced current caused by this condition was passed through the test meter. This condition showed a slight third harmonic, but not of enough value.

Case 7.—A set-up was made (see Fig. 7) whereby the exciting current of a 3-kw. 110-220/10-volt transformer was used as the testing current. In this circuit was inserted a 25-50 ampere Model 326 dynamometer-type laboratory standard wattmeter (for which the manufacturer claims an accuracy of 0.10 per cent for direct current and alternating current up to 133 cycles per second) and a 50/5-amp. current transformer in the secondary of which was the test meter. The voltage was regulated by a miniature single-phase induction regulator. Windings of the 3-kw. transformer were connected in multiple and excited to 132 volts. This gave a current of 20 amp. through the circuit.

TABLE I—Laboratory data pertaining to test of wave-form effect upon meter accuracy.

Test	Amp.	Power Factor	% Error	Amp.	Power Factor	% Error
Case 1	4	100	0.02+	4	0.50 lag	0.25+
	2	100	0.08—	2	0.50 lag	0.16—
Case 2	4	100	0.02+	4	0.50 lag	0.25+
	2	100	0.16—	2	0.50 lag	0.24—
Case 3	4	100	0.02—	4	0.50 lag	0.16+
	2	100	0.08—	2	0.50 lag	0.24—
Case 4	4	100	OK	4	0.50 lag	0.16+
	2	100	0.08—	2	0.50 lag	0.16—
Case 5	4	100	0.04—	4	0.50 lag	0.25+
	2	100	0.08—	2	0.50 lag	0.16—
Case 6	4	100	OK	4	0.50 lag	0.25+
	2	100	0.08—	2	0.50 lag	0.16—
Case 7	2	100*	0.28—	2	0.50 lag	0.09+
Case 8	2	100**	0.60—	2	0.50 lag**	12.20+
Case 9	2	100†	1.36+	2	0.50 lag†	2.20—

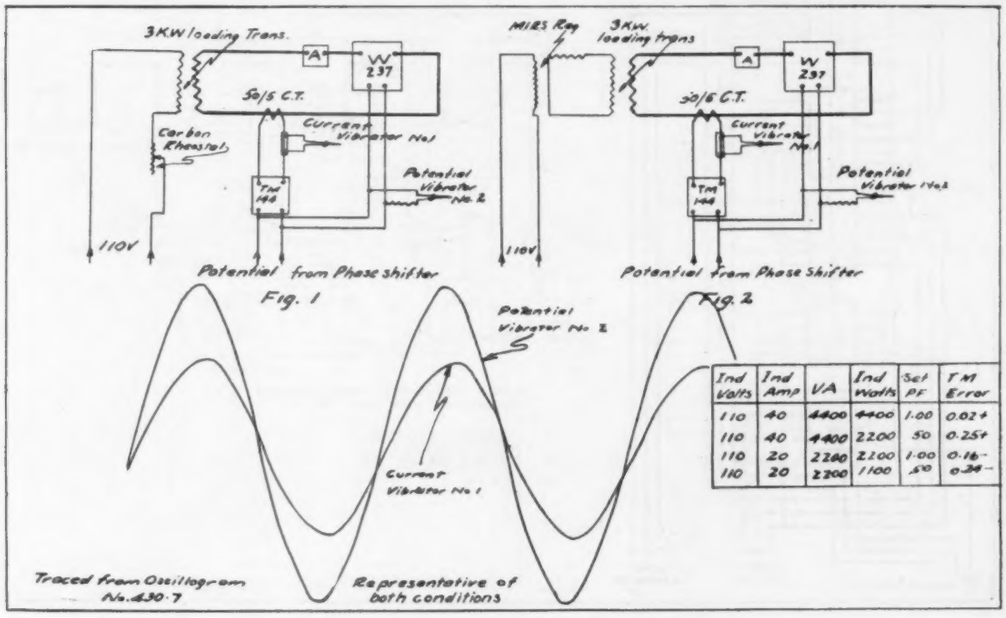
*The watts in this case held at unity power factor were 1,950 and at 0.50 lagging were 1,000. Normally the watts held would be 2,200 and 1,100 respectively.

**The watts in this case held at unity power factor were 450 and at 0.50 lagging were 225. Normally the watts held would be 2,200 and 1,100 respectively.

†The watts in this case held at unity power factor were 1,600 and at 0.50 lagging were 800. Normally the watts held would be 2,200 and 1,100 respectively.

A run was made on the test meter with 2 amp. through the 5-amp. coil at unity and at 0.50 power factor, current lagging. The watts held at unity power factor were 1,950, and at 0.50 lag the watts were 1,000. Normally the watts at unity and 0.50 lag would be 2,200 and 1,100, respectively, the dif-

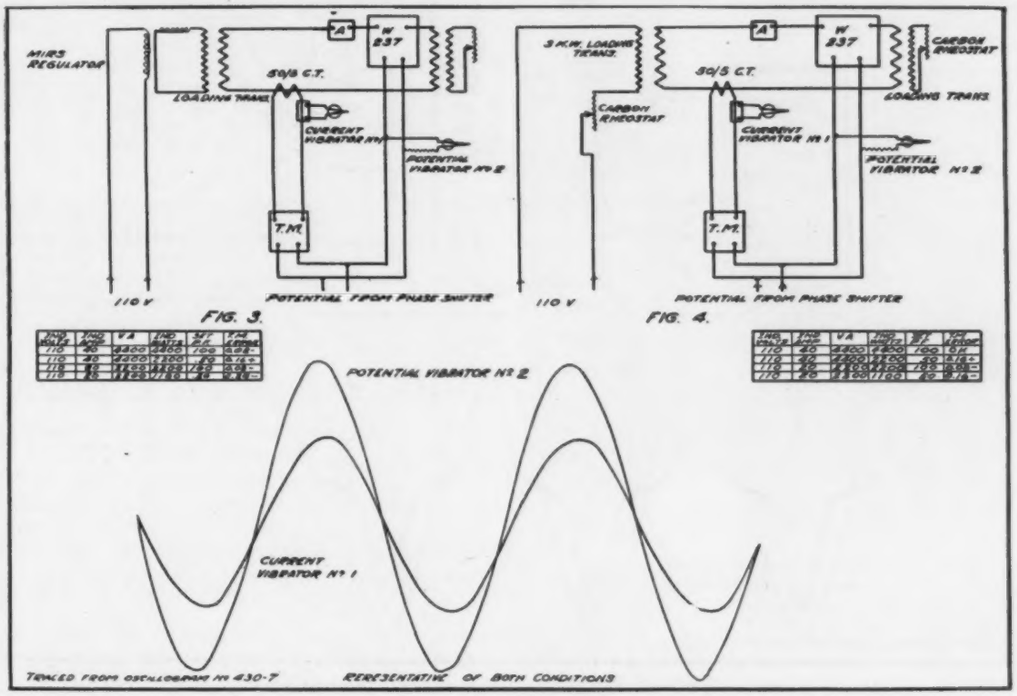
* Report prepared for special tests and investigations subcommittee of meter committee, Engineering Section. W. N. Lindblad, chairman.



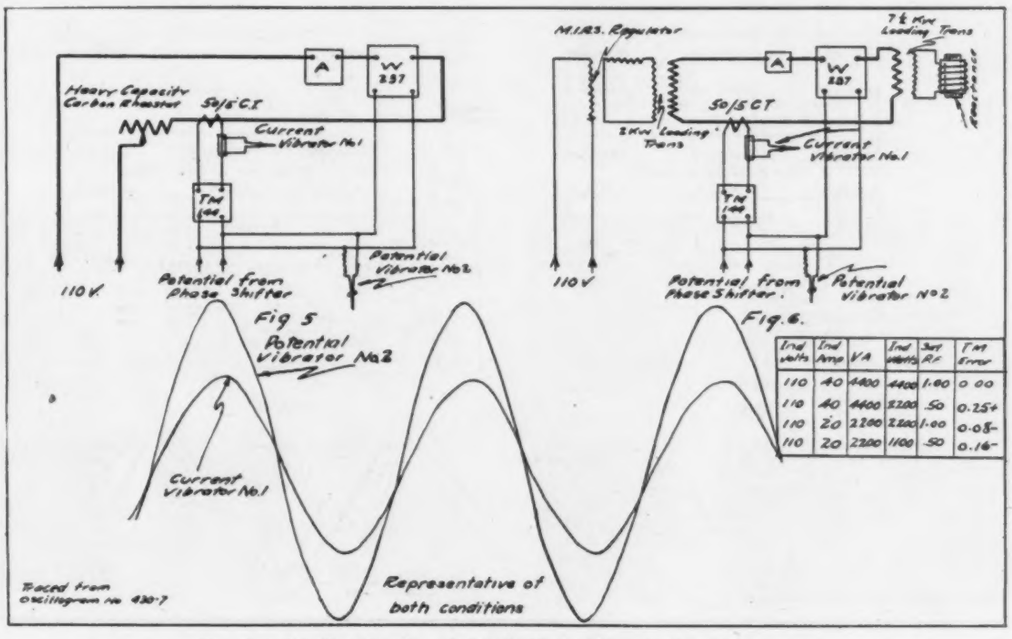
Figs. 1 and 2. Test circuits and data incident to investigation of wave form.

ference being accounted for by the third harmonic present in the current wave. This condition had no effect upon the accuracy of the test meter with relation to the indicating wattmeter.

Case 8.—A set-up was made, (Fig. 8) whereby a bank of 7½-kw. 110-440/10-volt transformer was connected star-delta, the wattmeter and current transformer with the test meter placed in the delta. Vol-



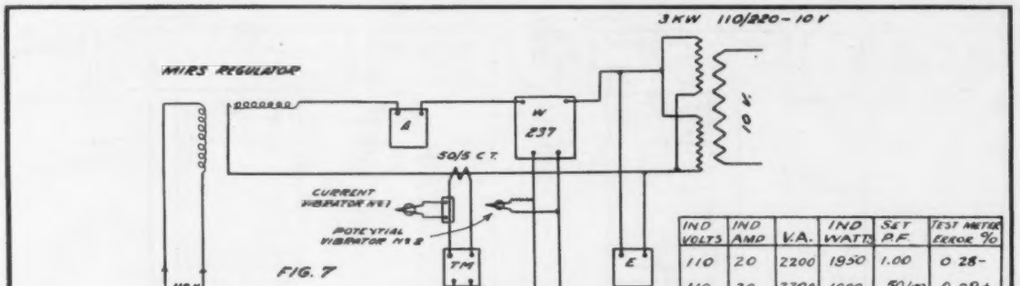
Figs. 3 and 4. Test circuits and data incident to investigation of wave form.



Ind volts	Ind Amp	VA	Ind watts	Set R.r.	P.M. Error
110	40	4400	4400	1.00	0.00
110	40	4400	2200	.50	0.25+
110	20	2200	2200	1.00	0.08-
110	20	2200	1100	.50	0.16-

Figs. 5 and 6. Test circuits and data incident to investigation of wave form.

tage to the loading transformers was regulated by three miniature induction regulators. A run was made on the test meter at 2 amp., unity and 0.50 power factor lagging. The watts held at unity power factor were 450 and at 0.50 power factor 225. Normally the watts would be 2,200 and 1,100, respectively, the difference being accounted for by the third harmonic present in the current wave. The accuracy of the test


3 KW 110/220-10 V
MIRS REGULATOR
W 237
50/5 C.T.
CURRENT VIBRATOR NO 1
POTENTIAL VIBRATOR NO 2
FIG. 7
110 V.
POTENTIAL FROM PHASE SHIFTER
IND VOLTS | IND AMP | V.A. | IND WATTS | SET P.F. | TEST METER ERROR %
110 | 20 | 2200 | 1950 | 1.00 | 0.28-
110 | 20 | 2200 | 1000 | 50 lag | 0.09+

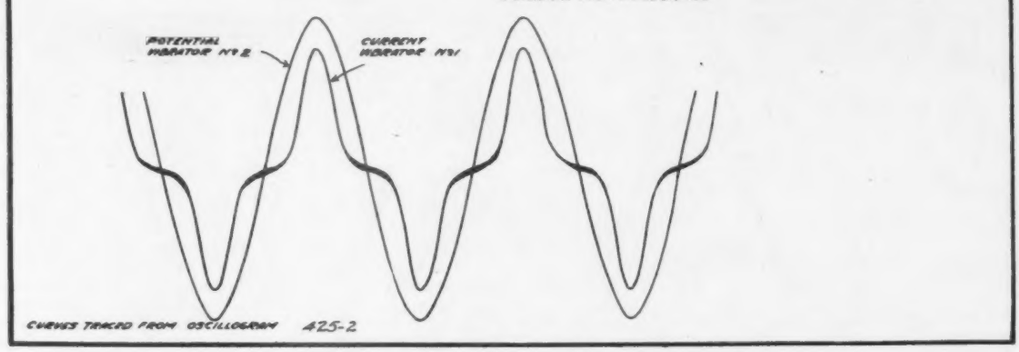
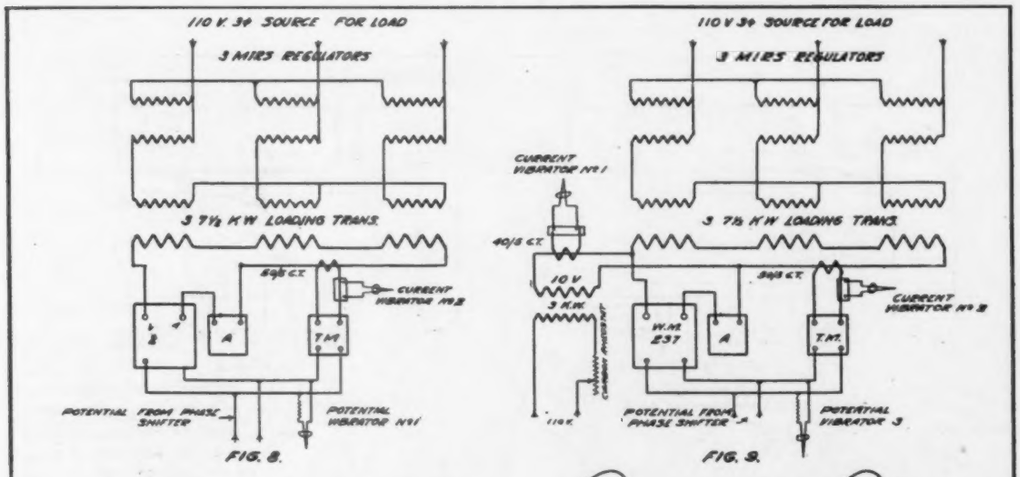


Fig. 7. Test circuit and data incident to investigation of wave form.



Figs. 8 and 9. Test circuits and data incident to investigation of wave form.

meter was noted. At unity power factor the test meter was 0.60 per cent slow, at 0.50 lagging was 12.20 per cent fast.

Case 9.—A set-up was made (Fig. 9) where a 3-kw. transformer, 110-220/10 volts, was utilized to superimpose a sine wave upon the third harmonic. See oscillogram Fig. 8-9. A run was taken on the test meter at unity and at 0.50 lagging with 2 amp. in the 5-amp. coil of the test meter. The watts held at unity power factor were 1,600 and at 0.50 lag were 800, when normally the watts would be 2,200 and 1,100 respectively. The accuracy of the meter was noted. At 2 amp. unity power factor it was 1.36 per cent fast, at 0.50 power factor lagging the meter was 2.20 per cent slow.

Test Meter Accuracies for Various Cases

In each case the test meter was a 5-amp. 115-volt type IB7. Current was passed through a 50/5-amp. current transformer. The laboratory standard watt-meter 50-and 25-amp. windings were used. (See Table I.)

Sludging of Transformer Oils*

This paper describes a special apparatus used for testing of transformer oils for sludging. To stimulate actual conditions as much as possible, heating was accomplished with copper wound coils insulated with cotton, varnished and baked like transformer coils. Heating was thermostatically controlled and provisions were made for circulating clean air over the oil.

TO DETERMINE the cause of sludging of transformer oil and to determine the relative tendency of various types of transformer oils to sludge, a special apparatus such as is shown in Fig. 1 was built.

The apparatus consists of a metal drum in which are installed six 1,000 c.c. beakers containing the transformer oil to be tested. In order to simulate as nearly as possible the conditions within a transformer, the oil in each beaker is heated by a coil of cotton-covered wire baked in transformer insulating varnish. An alternating current was supplied to the six coils in series. The coils are all of uniform resistance so that each beaker received the same amount of heat. The coils were of equal resistance and connected in series, therefore an equal amount of heat was generated in each.

Outside air was supplied to the compartment containing the coils and oils at the rate of approximately four liters per minute. This air was forced through a revolving distributing nozzle moving in a plane directly over the tops of the beakers and revolving at a rate of

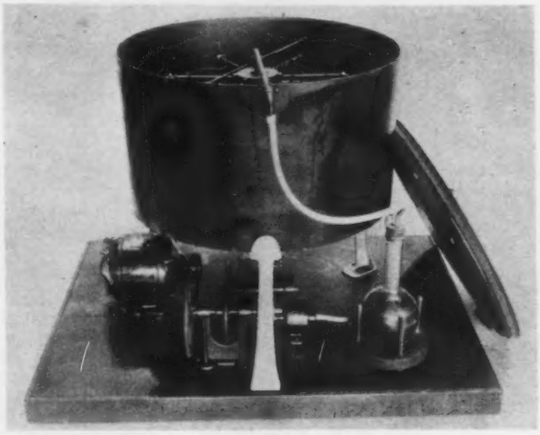


Fig. 1. Apparatus used in sludge test.

6 r.p.m. On the opposite end of the nozzle arm was an agitating vane which tended to distribute the air evenly over the beakers. Air was forced into the drum by means of a small gear pump. It was washed by bubbling through oil in a wash bottle any dust particles that might be in the outside air.

Each beaker contained a thermo-couple by means of which the oil temperature was measured. The thermo-couples were so placed at approximately midway between top and bottom of the oil that the average temperature for the beaker was determined. This average temperature is considered to be the normal operating temperature.

One beaker contained a bi-metallic contact that controlled the temperature and maintained it constant at any desired value.

Some special tests were made to determine the relation between the average temperature of the oil between top and bottom of a beaker and the average temperature of the windings of the copper coil. The aver-

* Report of special tests and investigations subcommittee of meter committee, Engineering Section. W. N. Lindblad, chairman.

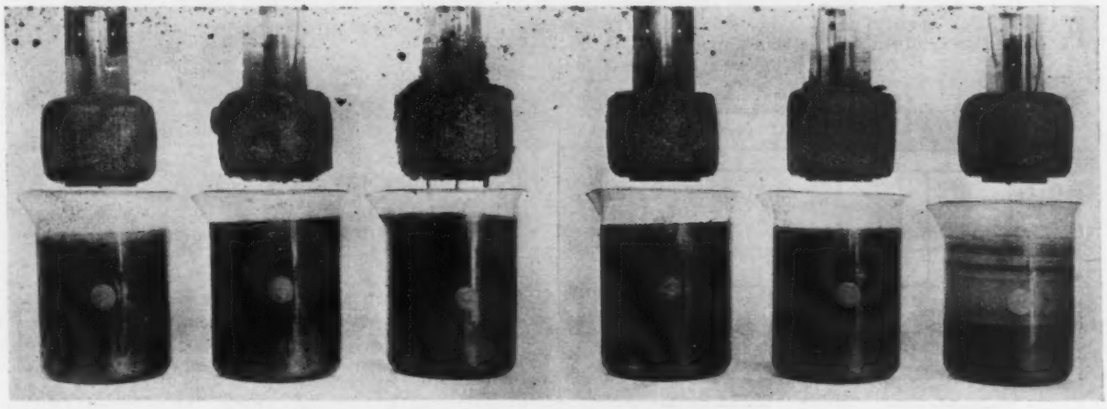


Fig. 2. Coils after 500 hours sludging in hot oil at 100 deg. C.

age oil temperature was measured by taking the average of a measurement near the top and one near the bottom of the oil, determined by means of mercury thermometers. The average coil temperature was computed from resistance measurements at two different temperatures.

The results of these tests are tabulated as follows:

Average oil temp. (deg. C)	Measured oil temp. (deg. C)	Top Average coil temp. (deg. C.)	Bottom Average coil temp. (deg. C)	Temp. diff. between coil and oil (deg. C)
100	107	93	129.7	29.7
90	96	84	115	25
60	63	57	72.6	12.6

The coil dimensions were: outside diameter 3⅝ in., inside diameter 2 in., height 2⅝ in. They were wound with approximately 840 turns of No. 20 double-cotton-covered, non-enameled, copper wire. The resistances of the coils were made the same value by varying the number of turns. This resistance was 6.6 ohms at 20 deg. C.

A photograph of the coils and beakers at the completion of the test is shown in Fig. 2. The coils had been suspended out of the oil for a sufficient length of time for the surplus oil to drain off. The amount of sludge formed on the surface of the coils and on the inside of the beakers was carefully scraped off and measured. A comparison of these amounts gives the relative sludging in the different types of oils.

The test was repeated with coils baked in various kinds of varnishes in order to determine the effect of varnish on the sludging.

A Voltmeter Method of Measuring Effective Resistance of Iron-Clad Coils*

A method of finding the effective resistance of iron-clad coils at low current values is described in this paper.

EFFECTIVE resistance of coils containing iron usually is determined by the relation

$$R = \frac{W}{I^2}.$$

When the current involved is only a few milliamperes and therefore is of about the same magnitude as the potential current of the wattmeter, the method loses its simplicity. For low current values another method involving only current and voltage values is here described.

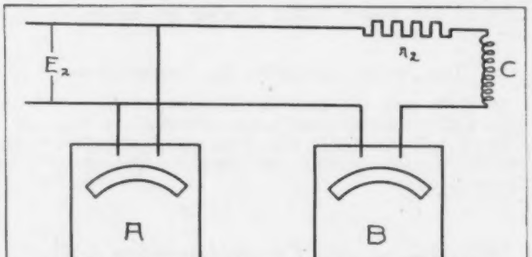


Fig. 2.

Two sets of readings are taken. In the first, the voltmeter A (Fig. 1) determines the voltage E_1 applied to the coil C through the low-reading ammeter B. In the second (Fig. 2), a resistance R_2 is added to the circuit and the applied voltage, E_2, is increased until the ammeter again indicates the current held in the first test. The effective resistance of C is equal to

$$\frac{E_2^2 - E_1^2}{2I^2 R_2} - \tfrac{1}{2} R_2 - R_1$$

R_1 being the resistance of the low-reading ammeter.

As the squares of the voltages are involved it is important to determine the most suitable value for R_2. Let aE_2 be the observed reading for E_2, "a" being the error factor. The value found for R will then be

$$\frac{(aE_2)^2 - E_1^2}{2I^2 R_2} - \tfrac{1}{2} R_2 - R_1$$

and the numerical value (y) of the error in R resulting from the error in E_2 will be

$$y = \frac{E_2^2 (a^2 - 1)}{2I^2 R_2}$$

$$= \frac{Z_2^2 (a^2 - 1)}{2R_2}$$

Differentiating with respect to R_2,

$$\frac{dy}{dr_2} = R_2^2(a^2 - 1) - R_1^2(a^2(a^2 - 1) - R^2(a^2 - 1) - 2RR_1(a^2 - 1) - x^2(a^2 - 1)$$

equating to zero and solving for R_2, the most suitable value for R_2 is found to be $\sqrt{(R + R_1)^2 + x^2}$ $\sqrt{(R + R_1) + x^2}$ is found in the first set of readings and is equal to

$$\frac{E_1}{I}$$

* Report of special tests and investigations subcommittee of meter committee, Engineering Section. W. N. Lindbald, chairman.

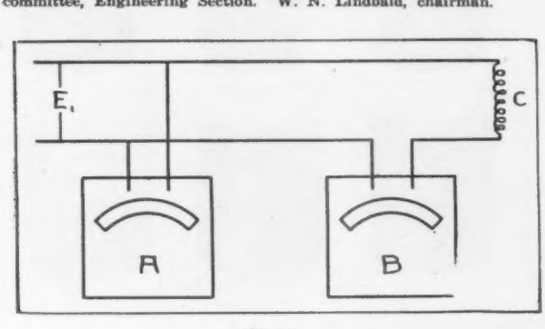


Fig. 1.

OVERHEAD SYSTEMS COMMITTEE REPORTS[2]

Line Construction Tools*

THIS report offers suggested specifications for pike poles and ladders, describes a crane truck for handling and transporting heavy equipment, describes also various warning signs and their supports, a presto gun burner equipment, and wire gins.

Pike Poles

A recent census of the pike-pole situation in California reveals that, due to the multiplicity of specifications on which they are purchased, it is necessary for the dealer to carry 37 varieties if he attempts to supply all demands. Each consumer has specifications or drawings from which purchases are made and the several specifications differ mainly in type of pike, type of ferrule, method of fastening same and diameter of poles. After making a collection of the various specifications, drawings and a record of all sizes used by consumers, the committee attempted to prepare a standard specification that would incorporate all the good features from the various specifications. The committee also has checked over the possibility of reducing the number of pike pole sizes to five as follows:

Length 12 ft., diameter 2 in. straight.
Length 14 ft., diameter 2 in. straight.
Length 16 ft., diameter 2 to 2.5 in. tapered.
Length 18 ft., diameter 2 to 2.5 in. tapered.
Length 20 ft., diameter 2 to 2.5 in. tapered.

Either a shoulder pike or a tapered pike as shown in Fig. 1 is acceptable, providing a proper ferrule is used with it.

As suggested at the January, 1928, meeting, experiments have been carried on with the hope of finding a varnish that would be sufficiently ductile to keep the wood from splintering and which will not chip off with rough handling, or be soft and sticky to the hands. To date no such satisfactory covering has been found.

Suggested Pike Pole Specifications

Scope

(a) These specifications cover wood pike poles to be used as construction tools.

(b) The specifications and accompanying drawings supplement each other; any dimensions, details or other instructions given in one and not in the other shall be executed as if indicated in both.

(c) The following requirements as to material, construction, tests and test methods shall apply.

Manufacture

(a) The steel for the pikes shall be made by open-hearth process.

(b) The wood handles may be either turned or shaved, and shall be made from one solid piece.

Material

(a) The handles shall be made of sound thoroughly seasoned and straight grained wood of any one of the following species:

Fir, douglas (Rocky Mountain type)
Fir, golden
Fir, noble
Fir, white
Fir. silver
Pine, norway
Spruce, red
Spruce, white
Spruce, sitka

(b) The handles shall be free from the following defects: large or loose knots, shake, cracks, rot, dote, wormholes, loose heart and surface season checks exceeding six (6) inches in length and one sixteenth 1/16 in. in width [the sum of the lengths of all checks appearing along the same grain shall not exceed twelve (12) in.] pitch pockets exceeding three (3) in. in length and one sixteenth (1/16) in. in width [the sum of the lengths of all the pitch pockets appearing along the same grain shall not exceed six (6) in.] and the number of pitch pockets in any one handle shall not exceed four (4) well distributed.

Warp shall not exceed one (1) in., measured at the point of maximum curvative, between the longitudinal axis of the pole and a straight line drawn through the extremities of this axis. Small sound intergrown knots well distributed will be permitted within five (5) ft. of either end. The total cross-sectional area of all knots in either end section shall not exceed that of one knot one-half (½) inch in diameter. Slight deviations in the grain due to knots are permitted.

(c) The steel in the spikes shall conform to the standard specifications of the American Society of Testing Materials for structural steel for bridges, under serial designation A7-24.

(d) The steel shall be free from all defects.

(e) The ferrules shall be made from a commercial grade of wrought-iron seamless tubing best adapted to the purpose. The ferrule shall make a tight fit on the handle.

Construction

The details of construction and assembly shall conform to the specified drawing.

Workmanship

(a) The workmanship shall be consistent with the best practice and the poles finished round and smooth.

(b) The finished pole shall be given two coats of boiled linseed oil. The second coat shall not be applied until the first coat is dry. The coating shall be sufficiently transparent to permit detailed inspection of the wood.

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[2] **R. G. Boyles,** Southern California Edison Company, chairman. **F. E. Dellinger,** Los Angeles Gas & Electric Corporation, vice-chairman. **Baker-Joslyn Company:** Howard Pratt. **Coast Counties Gas & Electric Company:** W. R. Van Bokkelen, A. E. Strong. **General Electric Company:** D. I. Anzini, J. C. Porter, W. C. Smith. **City of Glendale Public Service Department:** P. Diedrich. **Great Western Power Company of California:** G. H. Hagar. **Graybar Electric Company:** J. E. Crilly. **Hubbard & Company:** N. C. Husted. **Joint Pole Association (Oakland):** R. E. Hill. **Joint Pole Committee (Los Angeles):** J. E. Macdonald. **K-P-F Electric Company:** A. J. Pahl. **Line Material Company:** F. J. Gleiss. **Pacific Gas & Electric Company:** H. H. Buell, N. P. Carlson, Jr., L. J. Corbett, R. R. Cowles, C. E. Young, E. A. McGinty. **Los Angeles Bureau of Power & Light:** G. A. McDonald, H. L. Caldwell. **Los Angeles Gas & Electric Corporation:** E. R. Northmore, G. A. Riley, F. E. Dellinger, C. B. Judson. **Maydwell and Hartzell, Inc.:** H. F. Hartzell. **Pacific Telephone & Telegraph Company:** D. I. Cone. **San Diego Consolidated Gas & Electric Company:** A. S. Glasgow, K. B. Ayres. **San Joaquin Light & Power Corporation:** C. W. Wilson, C. E. Schnell, E. R. Banks, H. H. Minor. **Southern California Edison Company:** F. E. Blausey, C. B. Carlson, Harold Michener, J. O. Binney, C. A. Bennett, J. F. Hodges, R. G. Sheppard, E. R. Stauffacher, W. P. Champion, R. B. Guilbault, C. E. Heath, G. M. Richardson, W. E. Row. **Southern California Telephone Company:** G. E. Nott. **The Southern Sierras Power Company:** A. C. Putnam, E. Y. Porter. **Taper Tube Pole Company:** C. A. P. Duffie. **H. B. Squires Company:** E. S. Moreland.

* Report of pole line construction tools subcommittee of overhead systems committee, Engineering Section. F. E. Dellinger, chairman. K. B. Ayres, D. I. Anzini, E. R. Banks, J. E. Barhyte, H. L. Caldwell, W. P. Champion, R. B. Guilbault, C. E. Heath, E. A. McGinty, G. E. Nott, E. Y. Porter, A. E. Strong.

(c) Permissible variations indicated on the drawing shall not be exceeded.

Tests

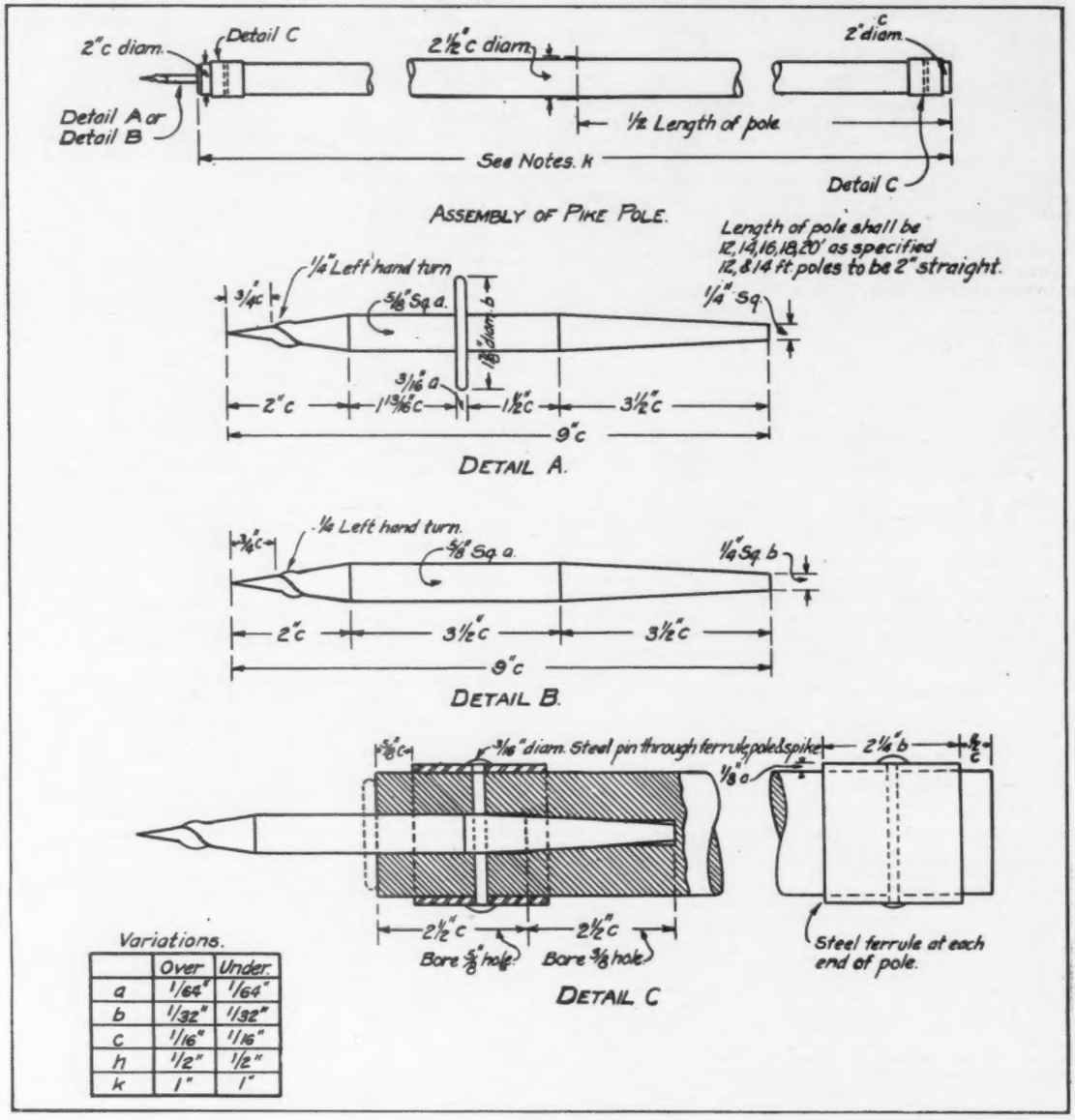
Each pole shall be subjected to the following test: The pole shall be supported at two points approximately four (4) in. from either end, a weight of one hundred pounds shall be suspended from the middle of the pole and the pole rotated through three hundred and sixty (360) deg. There shall be no indication of splitting or cracking in the pole during this test.

Rejections

Poles that do not meet the requirements of these specifications shall be rejected.

Inspection

Inspection and acceptance may be either at the point of manufacture or upon receipt at destination at the option of the buyer. If inspected at the manufacturer's plant, the manufacturer shall give the buyer or his representative such access to his works during working hours as is reasonable and necessary to



Variations.

	Over	Under
a	1/64"	1/64"
b	1/32"	1/32"
c	1/16"	1/16"
h	1/2"	1/2"
k	1"	1"

Fig. 1. Pike pole details.

determine the suitability of the material to be supplied, and shall furnish all the necessary apparatus, labor and other facilities for making the inspection as herein called for without cost to the buyer. The manufacturer shall eliminate all material that is defective according to these specifications before offering any lot for inspection or before shipping. Neither inspection nor the buyer's acceptance shall relieve the manufacturer from obligation to furnish material in accordance with these specifications.

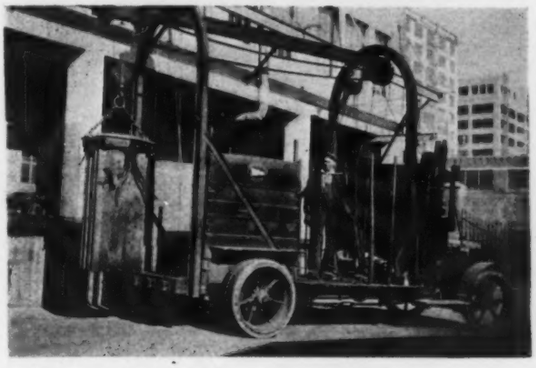


Fig. 2. A crane truck for distribution construction.

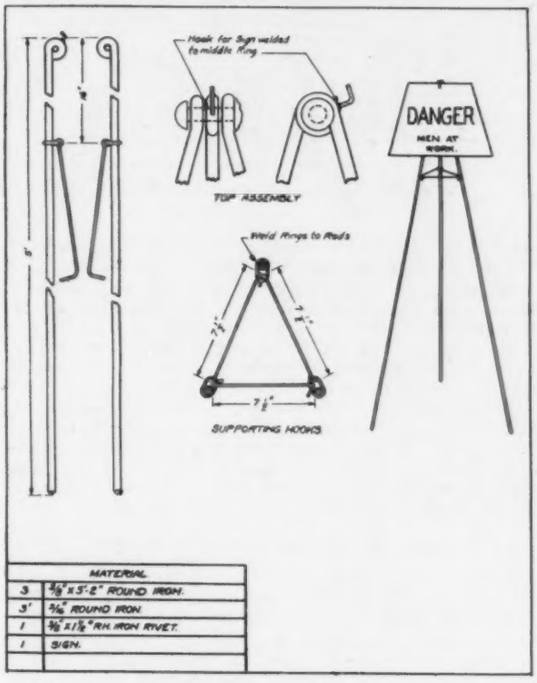

Hook for Sign welded to middle Ring
TOP ASSEMBLY
Weld Rings to Rods
SUPPORTING HOOKS
DANGER
MEN AT WORK
MATERIAL
3 | 3/8" x 5'-2" ROUND IRON
3' | 5/16" ROUND IRON
1 | 3/8" x 1 1/2" R.H. IRON RIVET.
1 | SIGN.

Fig. 3. Tripod details for danger signs.

Ladders

As in the case of pike poles the diversity of specifications among the companies would require not less than 182 varieties of ladders if all of the different specifications were to be complied with. This figure is based upon sizes varying in steps of two feet from 20 to 44 ft., upon variety in step spacing, width, types of rungs, rodding, bracing and various specials mentioned in the companies' specifications as existent at the present time. The results of this condition affect both the stores and accounting departments.

After a thorough study of most of the existing specifications a study of the various types put out by the manufacturers, and the proposition put up to the con-

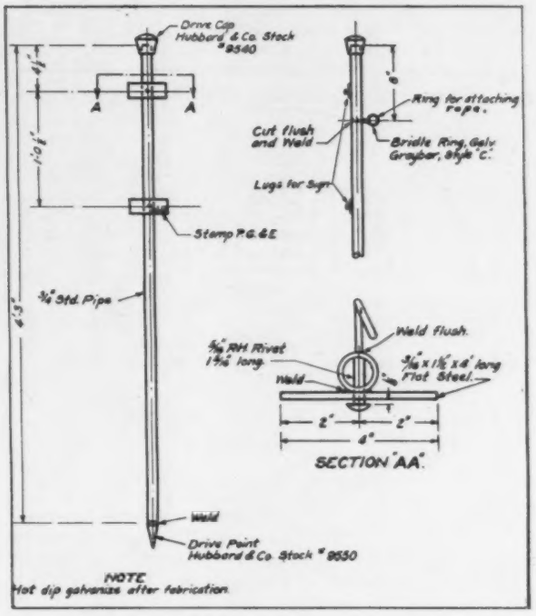


Fig. 4. Staff-type support for warning signs.

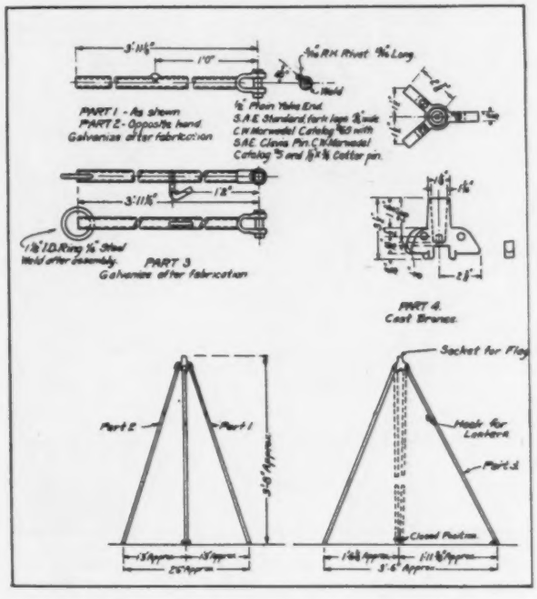


Fig. 5. Folding tripod support for warning signs.

sumers regarding standardization, it seems that the majority are in favor of adopting a standard specification and attempting to standardize as much as possible upon certain sizes of ladders. In fact, a few of the utilities have already managed to get together and standardize on sizes of 24, 32 and 40 ft. for extension ladders.

This committee also attempted to limit the rung spacing of ladders to two sizes, 12 and 14 in., and it is suggested now that we go further and limit rung spacing to 12 in. which is now considered standard by the majority of the ladder manufacturers and the U. S. Department of Labor Specification No. 351. It is suggested further that a standard width be adopted. This will be a benefit in replacing parts of extensions.

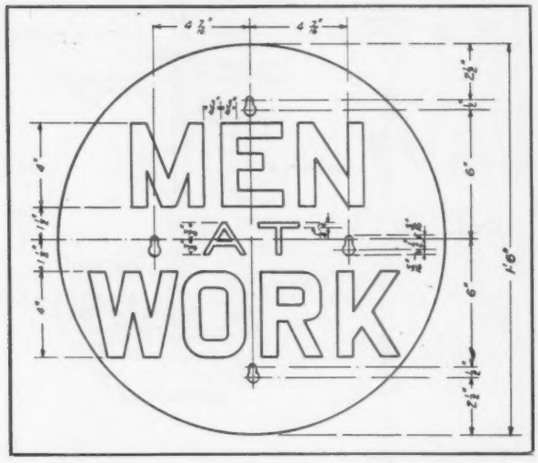


Fig. 6. A warning sign "men at work" made from No. 14 galvanized sheet steel, painted with three coats of brushing lacquer. Letters on red background.

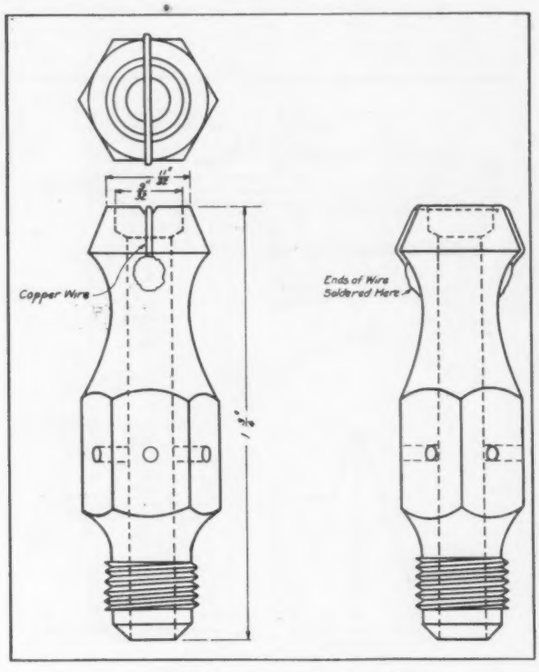
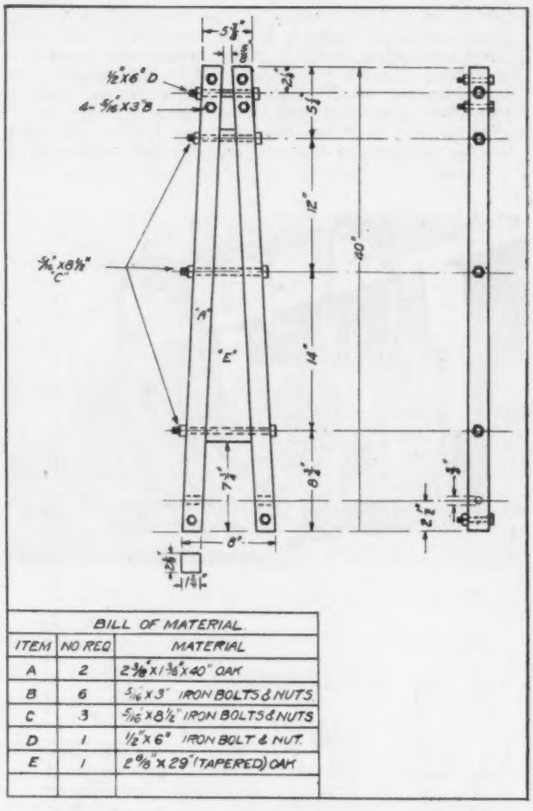


Fig. 7. Prestolite nozzle with attachments.



BILL OF MATERIAL.

ITEM	NO REQ	MATERIAL
A	2	2⅜"x1⅜"x40" OAK
B	6	5/16"x3" IRON BOLTS & NUTS
C	3	5/16"x8½" IRON BOLTS & NUTS
D	1	½"x6" IRON BOLT & NUT.
E	1	2⅜"x29" (TAPERED) OAK

Fig. 8. Wire gin for line construction department.

When all have standardized as much as possible on these sizes and conformed to the one specification, the manufacturers will be able to work on a quantity production basis, they will be willing to carry a reasonable stock so that we may all draw on same, and the benefit will be felt by all parties concerned.

At the present time specifications and drawings are being made incorporating all of the good points brought out in the various specifications and drawings which have been submitted by consumers and it is hoped that these specifications and drawings will be accepted by the several companies to the benefit of all.

Crane Truck For Heavy Equipment

A truck equipped by the Los Angeles Gas & Electric Corporation for loading, unloading and transporting equipment weighing up to two tons is shown in Fig. 2.

This truck was designed primarily for the handling of large transformers for the underground system where it is possible to lower into or raise transformers from vaults and for handling potential regulators and other equipment in substation work, but it has been found to be valuable also in handling large transformers in overhead work and it is possible that other uses may be found where it may be taken advantage of.

The equipment is mounted on a 5-ton truck. The crane track extends about 6 ft. back of the truck bed, the lifting hook when at the top position is 9 ft. above the bed of the truck and the bed of the truck is 26 in. above the ground when the truck is not loaded. The width between the arches is 5 ft. 5 in. in the clear, and

the length in the clear is about 12 ft. The lifting capacity is 4,000 lb. with a safety factor of four.

The cost of the truck was	$5,100
Equipment installed	1,195
Total cost	$6,295

Warning Signs and Supports

Several types of warning signs and supports for same, which are inexpensive, light, collapsible and convenient to use are shown in Figs. 3, 4, 5 and 6. They are shown here for those who may desire to make use of them.

Presto Gun Attachment

A method used by the San Diego Consolidated Gas & Electric Company to prevent the torch flame from going out is shown in Fig. 7. This is used in connection with the Nobile-Cox regulator and consists of a small wire soldered across the outlet and it works very well except that when the flame catches inside the nozzle and heats it up the solder melts and spoils the idea. However, as long as the nozzle is working properly the solder stays in place.

This is only part of an idea which one of their line foremen is combining into a new design of the entire nozzle which will make it easy to clean so that the

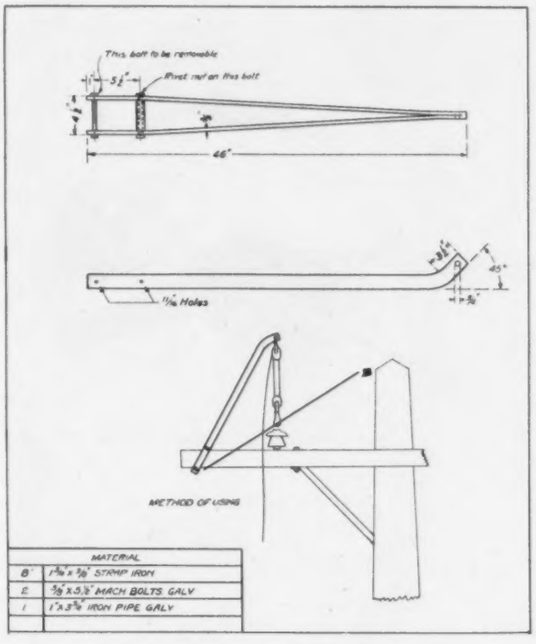

This bolt to be removable
First nut on this bolt
46"
1¼ Holes
METHOD OF USING
MATERIAL
B 1⅝" x ⅜" STRAP IRON
E ⅜" X 5⅜" MACH BOLTS GALV
I 1" x 3⅞" IRON PIPE GALV

Fig. 9. Another style of wire gin.

nozzle can be used again after having become fouled. The present nozzle becomes dirty very rapidly and since they are not cleanable the expense of new nozzles is nearly as great as the gas which they use.

Wire Gins

A wire gin used by the Pacific Gas and Electric Company, at the Sacramento division, for lifting large wires into position on crossarms is shown in Fig. 8. Figure 9 shows a wire gin used by the Los Angeles Gas & Electric Corporation for the same purpose. This can be turned in either direction and may be used for lifting the wire from the ground or up to the insulator.

This subcommittee had hoped to be able to assemble data on line trucks, earth-boring machines and tools of a special nature, but owing to the lack of enough definite information this will have to be omitted as far as this year's report is concerned.

Fuses, Fuse Tubes, Cutouts and Oil Switches*

THIS report is in general a discussion on fuses, fuse tubes and cut-outs. The subject of air-break and oil-break sectionalizing switches is not discussed herein, but will be at some later date. However, several of these switches are shown in Fig. 1.

In considering the subject of this report studies and tests recently conducted as well as past operating experience in their use require that the following points be considered:

(a) General requirements
(b) Simplification
(c) Standardization
(d) Interchangeability of fuse links and link holders
(e) Standard current-time characteristics of fuse links.
(f) Rupturing ability
(g) Fuse link holder material
(h) Tests.

General Requirements

One of the most important items under general requirements is carrying capacity. Preliminary study shows that there is no definite understanding as to what a cut-out will carry without overheating, changing or weakening the insulation. Flashover and leakage current seems to have been given some consideration as well as radio interference.

Simplification and Standardization

These two subjects are so closely allied that they are hardly separable. A great deal can be accomplished by a study of these items and recommendations will be made as to possible standardization without any one manufacturer losing the opportunity for individual endeavor.

In Figs. 2 and 3 are shown many designs, shapes and sizes of cut-outs to select from, and of course the illustrations do not cover the field completely. Very few of the fuse links of different manufacturers are interchangeable even for cut-outs of the same capacity. None of the link holders are interchangeable.

It is true that each manufacturer claims certain advantages for his particular design and no doubt there are certain advantages for each design. But when it is considered that the air-expulsion principle is the fundamenal principle used in all cut-outs to interrupt the circuit there comes to mind the thought that more attention should be given to workmanship, material, ample carrying capacity and interchangeability.

Fuse Links and Link Holders

Interchangeability of fuse links and, if possible, link holders would be a very desirable feature. The

* Part I of report of pole line structures, devices and maintenance subcommittee of overhead systems committee, Engineering Section. C. E. Young, chairman. J. E. Binney, J. E. Crilly, C. P. Duffie, F. J. Gleiss, R. B. Guilbault, G. H. Hagar, H. F. Hartzell, G. L. Hill, N. C. Husted, G. A. McDonald, E. A. McGinty, H. H. Minor, E. S. Moreland, G. E. Nott, A. J. Pahl, J. C. Porter, G. M. Richardson, W. E. Row.

item of reduced warehouse stock both for the consumer and the manufacturer makes this subject worthy of study. When the subject is considered from the maintenance standpoint, any change that reduces the number of parts a trouble man is required to carry is a desirable thing to work for.

Current-time Characteristics

Preliminary study shows a very wide range in current-time characteristics. A fuse link of one manufacturer stamped "100 amp." may be the equivalent of a 150-amp. unit of another manufacturer. Very few manufacturers have furnished current-time curves of their fuse links and due to the lack of this information the operating engineer is unable to determine what fuse link to install to meet certain requirements. Unless the operating engineer has the current-time characteristics of his cut-outs he may install a fuse link in a branch circuit that will have a greater time lag than the relay in the main circuit and as a result the main circuit is interrupted instead of only the branch circuit in case of trouble on the branch circuit.

Again, if the time lag of the fuse link is too short the fuse may interrupt the circuit for momentary overloads, a very undesirable feature particularly where there is a load of larger motors.

Rupturing Ability

Quite naturally in addition to the other requirements a cut-out must interrupt the circuit when the conditions require it. A great deal of work has been done toward increasing their interrupting capacity, particularly under short-circuit conditions. Several reports of these tests have been made. One report will be found in the appendix 2 in the overhead systems committee (National Electric Light Association) report for 1923. Another will be found in the electrical apparatus committee report (National Electric Light Association) for 1925.

Proper interruption of the circuit under moderate overload and low power-factor conditions is being given considerable study and indications are that this important requirement has been somewhat overlooked. Also there are certain times that a cut-out must be opened under load conditions. This is particularly true if the load is made up of one or more street-lighting transformers.

On the whole, all of the requirements for cut-outs must be given consideration according to their relative importance, realizing that the cut-outs must function year after year and not just momentarily when a short-circuit occurs.

Fuse Link Holder Material

This subject has been given a great deal of study during recent years by both manufacturers and users. It is a subject that is difficult to determine by test alone. Operating conditions and climatic conditions as well as the duty to which the cut-out is put all affect the result. The most commonly used materials are fiber, Bakelite, porcelain and glass. Probably the

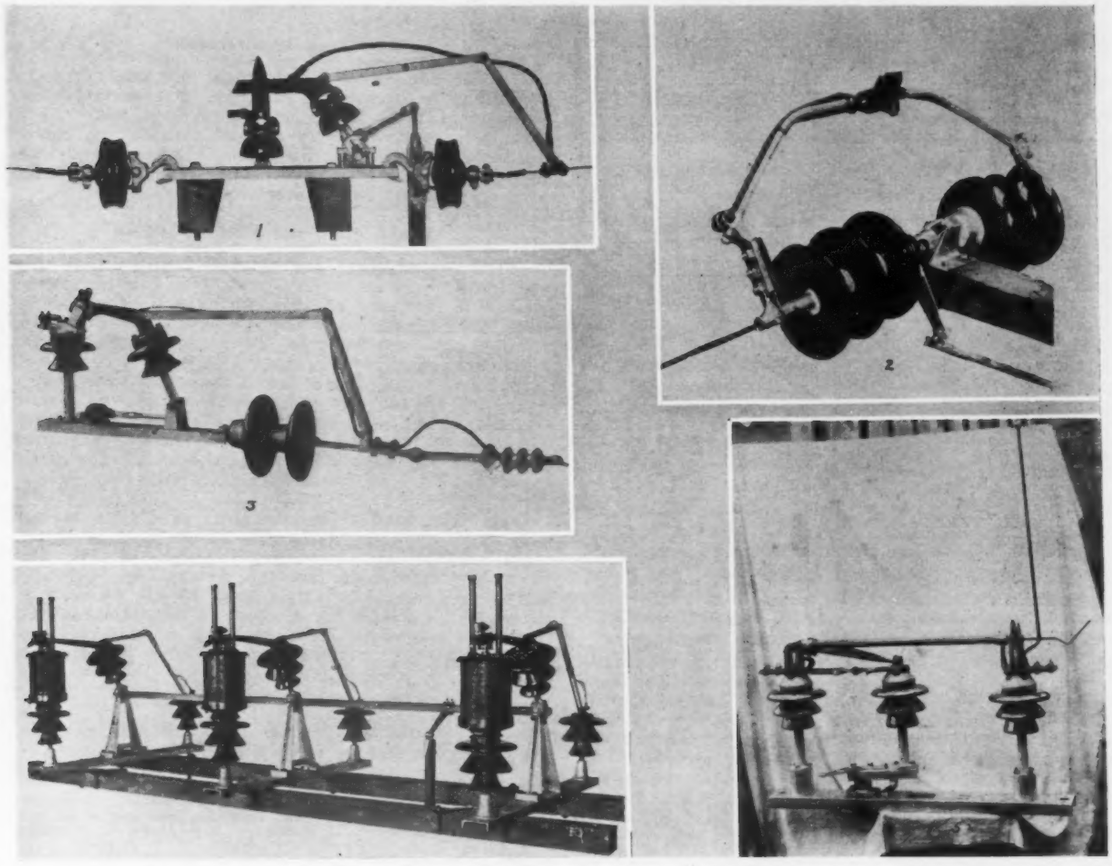


Fig. 1. Air-break and oil-break sectionalizing switches, 4 to 66 kv.

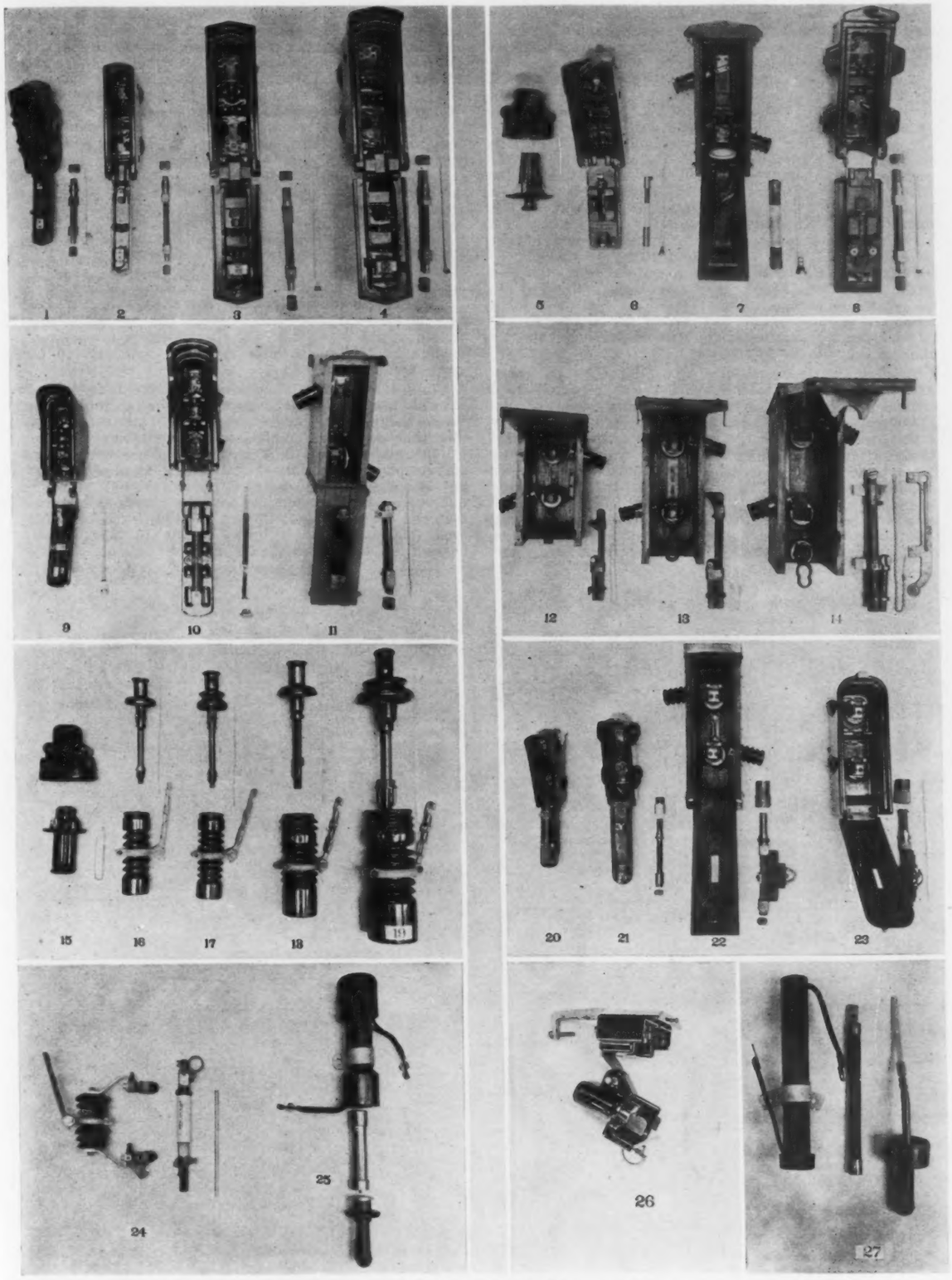


Fig. 2. Enclosed and open cutouts, 7.5 kv. and lower.

most widely used are fiber and Bakelite or combinations of these two. One of the principal troubles encountered in practice with this material is carbonization and attendant leakage and burning.

In commenting upon the reason for failure of link holders which caused cut-outs to fail at currents lower than their rated interrupting capacities in some recent fuse tests, the statement was made by one of the manufacturers that it undoubtedly was due to the fact that the cartridge which failed had been used previously for heat tests at 100 per cent rating of the fuse. Their contention, which probably is true, is that the cut-out in actual practical use will not be operated at sustained full load for any long period and that the carbonization of the tube would not be so apt to take place as in the test. This was proved by the fact that when the same cut-out was equipped with cartridges which had not been subjected to the sustained temperature of full load operation for a long period, and again was tested for rupturing capacity, the cut-out exceeded the rupturing capacity claimed by the manufacturer.

Another cause of failure of a Bakelite cartridge which was exposed to the weather was reported by a central California utility. The utility used on its 11,500-volt lines an 18-in. tube supported horizontally with 15-in. clearance between terminals. The fuse tubes after a season's weathering would leak over the outside of the tube, distinct carbonized paths being developed. This probably was due to the surface becoming erroded and dust covered. The presence of moisture then caused leakage which soon carbonized the tube. Instances resulting in transformer damage have occurred where the leakage current over the tube was sufficient to trip the feeder at the substation.

This same utility recently has changed its standard fuse tube to porcelain instead of Bakelite. Breakage in handling with the fuse puller is quite an item with this type of tube. A wet-process porcelain tube of ¾-in. outside diameter and with ¼-in. wall is used and is quite strong except under impact. Breakage may be lessened by the use of a slightly different type of fuse puller. Breakage from other causes is not excessive.

Considerable radio interference difficulty also has been experienced with these unfilled fuse tubes. This has been particularly noticeable with the Bakelite tubes refered to. It seems to be due to internal carbonization or metalization of the tube which provides a parallel path for the current with resultant sparking and radio interference. Links removed from tubes that have given trouble are corroded and pitted at several places along their length. The porcelain tubes that now are being used have not been in service long enough to tell whether or not they will develop the same trouble.

Glass tubes as well as porcelain have been in successful use by some companies for a long time. While they both are more subject to breakage in handling than the other materials, carbonization probably is entirely absent. The metalizing of the interior surface may occur, however, if the design of the cut-out is not such as to prevent it.

The use of fiber has been quite common, but this material does not stand up any too well in the weather. Such cartridges have been known to warp badly enough so that they could not be engaged in the

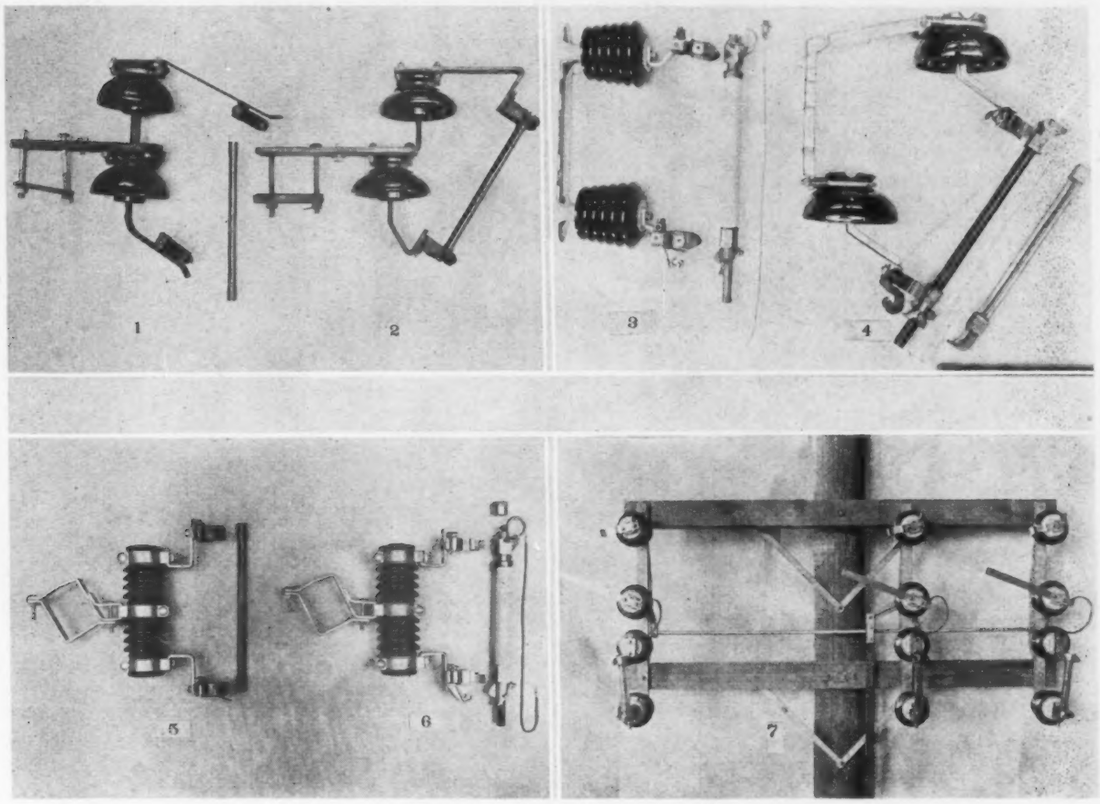


Fig. 3. Open cutouts and fuse switch, 7.5 to 17 kv.

contacts. A tube recently brought out by several manufacturers is a combined Bakelite and fiber tube, the fiber enclosed by a Bakelite tube. Thus the advantages of both materials are obtained and at least some of the disadvantages are avoided. Another manufacturer is encasing a fiber tube in a porcelain protector. Both of these methods are a great improvement over the fiber tube alone.

It is believed that the answer does not rest alone with the tube, however. The temperature at which the tube is operated continuously over long periods of time should be given careful thought. This temperature depends upon the fuse rating and upon the cut-out design. This design must be such that the heat will be carried away readily and not increased by poor contacts or other weaknesses in the assembly. There has been great improvement in cut-outs during recent years and each of the several manufacturers of these devices has put a great deal of thought and effort into the subject as is shown by the better operating characteristics of the products.

Tests

There follows an outline of some tests conducted by a southern California utility. In making these tests the idea was to simulate actual service conditions in so far as was practicable in a laboratory set-up, rather than to check on factory test values. The following assumptions were made on what may be termed maximum service conditions of a fuse cut-out:

1. The fuse may operate at 100 per cent rated capacity during peak load periods at indefinite intervals.
2. Load may increase during special occasions to a point where fuse would blow.
3. Following such conditions the fuse may be subject to short-circuit conditions through failure of the transformer so protected.

Based upon the above assumption tests were conducted in the following order:

1. Operating characteristics at 100 per cent rated capacity of fuses to determine heating, charring, etc.
2. Operating characteristics at 150 per cent rated capacity of fuses to determine time required for fuse to blow at this load and to determine extent of additional charring, throwing of metal, etc.
3. Short-circuit characteristics at 15 times rated capacity.
4. Short-circuit characteristics at 20 times rated capacity.
5. Short-circuit characteristics at 25 times rated capacity.
6. Short-circuit tests to determine time required to clear the circuit (determined through oscillograph records) and action of the cut-out under these conditions.

All tests were conducted at 2.3 kv. and apparatus was so set up that this voltage would be maintained across the cut-out terminals on open circuit.

Four types of primary cut-outs were submitted by three manufacturers for this test. They will be designated as A, B, C and D. Their ratings were as follows:

A—No rating given but it is of much higher capacity than the other three.
B—60 amp. 7.5 kv.
C—60 amp. 4.5 kv.
D—60 amp. 2.5 kv.

Following are the results of the tests.

Load Tests on Fuse Cut-Outs

Fuse Capacity (amp.)	Test Current (amp.)	Temp. Rise (deg. C.)	Remarks
		Cut-Out A	
50	50	21	Operation O.K., no scorching.
50	75	....	Operation O.K., fuse blew in 4 min. 53 sec., no scorching.
		Cut-Out B	
60	60	78	Fuse began to smoke, the fuse wire was scorching the link holder, full length. Disconnected before fuse blew.
60	90	....	Started with cut-out cold, blew in 7 min. 22 sec. Link holder badly burned.
		Cut-Out C	
30	30	18	Operation O.K.
30	45	....	Operation O.K., blew in 22 sec.
60	60	25	Operation O.K.
60	90	....	Operation O.K., blew in 4.5 sec.
60	90	....	Started with cut-out cold, blew in 55 sec.
		Cut-Out D	
60	60	25	Operation O.K., no scorching. Blew in 41 sec., explosion chamber slightly scorched, tube warped.

Short-Circuit Tests

Amperage (effective)	Voltage (effective)	Time Duration (cycles)	Remarks
		Cut-Out A	
744	2,370	1	Operation O.K.
1,100	2,370	1	Operation O.K.
905	2,410	0.5	Operation O.K., with the same connections and capacity as test No. 10. There the current was 1,437 amp. Here the current was cut off before it made a complete cycle.
		Cut-Out B	
757	2,370	12	Cleared the short, but blew the bottom end of the link-holder tube off, and welded the top cap to the metal band at the top of the link holder. All the life seemed to be out of the tube material due to the excessive heating during the load tests. No further tests were made on this fuse.
		Cut-Out C	
751	2,370	11	Operation O.K. Hot metal from the fuse was blown from the bottom of the cut-out back up into the cut-out. Explosion tube showed no marks.
1,155	2,370	3.5	Operation O.K. Blew all of the fuses out, small amount of hot metal was blown up in the cut-out. Tube showed no marks.
1,437	2,310	23+	Cut-out was destroyed and opened the short when cut-out fell apart. Oscillogram shows that in 2 cycles the fuse blew and cleared the short for approx. 1/5 cycle. Housing broke and arc continued until cut-out fell apart. O.C.B. did not open. Housing broke just below supporting pin insulator, deflecting part of the gases up into cut-out causing arc-over between primary terminals. Metal and porcelain badly burned. Door broken off.
		Cut-Out D	
751	2,370	13	Operation O.K. Explosion tube slightly blistered.
899	2,370	9	Operation O.K. All of fuse link blown out, increasing blistering in tube.
1,182	2,370	23+	Cut-out destroyed and failed to open short. O.C.B. cleared short. Explosion tube broke in upper compartment of cut-out and discharged gases into housing, causing an arc-over across primary terminals. Door was blown open, contacts badly burned and porcelain around edges of door broken.

Care of Poles and Crossarms*

POLE-USING utilities are beginning to realize the necessity of providing means for preserving pole-line timber. The only substitute for wooden poles and fixtures is steel or concrete the cost of which is prohibitive at present competitive prices, except in the erection of important permanent lines when steel and concrete are most economical and their use is recommended. The life of wood poles and crossarms therefore should be prolonged in an effort to conserve timber, making it necessary to combat decay, termite ravage, and the destruction of poles from grass fires.

Poles

In so far as combating termite is concerned there is in California an organization known as the termite investigation committee. This committee is making a thorough study of the termite situation in the state, details of which will be published from time to time and no doubt will be of interest to members of the Pacific Coast Electrical Association. Many of the engineers of the overhead systems committee are members of this investigation committee and are quite familiar with developments that are taking place. No doubt when the committee has completed its work it will be found that whatever treatment of timber is recommended to prevent termite infection also will prevent decay. It may be found that some species of timber in certain localities will require only butt treatment insofar as poles are concerned, while some timber necessarily will require full-length treatment. No treatment or preservative has been tried in this state as of this date that gives better results than creosote.

Painting of poles tends to preserve them to a great extent above ground line and no doubt gives the line a better appearance, providing however the paint used is not of too conspicuous a shade. For example it is found that dark green paint gives the best appearance and service and causes less criticism from the public. There are ordinances in some of the smaller towns requiring poles to be painted white, black, or a specified area of the pole to be painted both black and white. The use of these colors should be discouraged.

Preserving Poles Originally Set Untreated

In this connection a large pole-using utility in California has done some extensive preservation work. Other utilities have done a limited amount. The practice is to dig around the standing poles, removing all the decay for a depth of at least two feet and then treat the poles by various means, such as spraying with creosote, or charring with the flame of a torch followed by a treatment of creosote or special chemical preservatives. It has been determined beyond a doubt that no second-hand poles untreated should be set if the utility expects to obtain economical life from the pole. In fact it has been found by experience that second-hand poles should be treated before being put back into service. This practice is being followed by a number of pole-using utilities with very good results. Satisfactory treatment can be accomplished by standing thoroughly dry unpainted second-hand poles in a vat of creosote for from eight to twelve hours, allowing the creosote to be absorbed. This can be accomplished only during hot weather. It is hoped that since the use of treated poles is universal in the state the necessity of having to treat or stub them will be unnecessary, and that the life of the butt of the pole will be equal to that above ground.

Stubs

There is a difference of opinion with regard to the advantage or disadvantage of treating pole stubs. Some engineers recommend butt treatment, others full-length treatment of stubs. If, however, the best results are to be expected full-length treatment is recommended. In any event care should be exercised to see that all decay is removed from the poles to be stubbed, and wherever termites are found some means should be taken to destroy them. In order to determine when poles should be stubbed, one utility has provided specifications for use of its employees in determining the extent to which a pole can become weakened by decay before stubbing is necessary. Any pole-using company no doubt would benefit by the use of some such definite instruction for the use of pole-testing crews.

Pole Fixtures

In gaining poles for the attachment of fixtures, particularly poles having full-length treatment, it is essential that the gains be brush-treated with some reliable preservative. In fact it is recommended by a majority of engineers that all gains should be treated in this manner whether the poles are full-length treated or not.

The larger pole-using utilities have tried various means of preserving crossarms with the result that it has been found the best practice to purchase well seasoned timber, giving it either a hot-dip treatment of a good grade creosote oil, or two coats of paint. This treatment or painting minimizes checking and preserves the crossarms as well as improving the appearance of the structure.

Labor-Saving Equipment

The use of pneumatic tools for shaving, painting, gaining, and boring poles is becoming an important factor in the light of economy. The cost of equipment to provide means for operating labor saving tools, and the tools themselves, is prohibitive unless there is sufficient work to justify the purchase and installation of the apparatus. The work therefore should be centralized either in the operating companies' territory or by the pole dealer. In this connection it is suggested that specifications be prepared by pole-using utilities covering any or all of the requirements in view of purchasing poles treated, shaved, painted, gained and bored for steps, etc. By centralizing this work, labor-saving equipment can be made use of and a saving in labor effected.

* Part II of report of pole line structures, devices and maintenance subcommittee of overhead systems committee, Engineering Section. Committee list given on a preceding page with Part I of this report.

Maintenance of Distribution Transformers*

MAINTENANCE of distribution transformers is a subject of great importance to operating companies throughout the country and the data obtained from various utilities in California show a wide variety of polices followed. The average unit cost of distribution transformers is comparatively low, but the aggregate cost of the many units now in use on any utility system is sufficiently high to justify the expense of some method whereby the transformers may be kept in good operating condition throughout their useful lives. Proper maintenance means a saving in the number of failures, reduces depreciation of transformers and accessory equipment, insures continuity of service and improves operating conditions on primary circuits. This subject has much in common with the

* Part III of report of pole line structures, devices and maintenance subcommittee of overhead systems committee, Engineering Section. Committee list given on a preceding page with Part I of this report.

subjects of Transformer Protection and Transformer Loading, which are being covered by separate reports this year.

Attention must be given to routine inspection and light repairs of distribution transformers while in service to insure low upkeep costs and uninterrupted service to consumers. Experience has shown that this should be done once every two or three years. Too much importance cannot be attached to the maintenance of old transformers in the shop before being again placed in service.

The problem of correcting the voltage ratio of old transformers to make them suitable for use on the voltage of present-day systems is confronting operating companies. The only satisfactory methods so far worked out are:

(1) use of an auto-transformer for bucking the voltage and

(2) cutting out turns on the secondary winding.

Operating companies also are investigating the advisability of replacing distribution transformers that have been in service many years to determine whether it is good economy to retain these older designs owing to the fact that modern transformers are far more efficient than those of early manufacture, especially as regards core loss, the cause of the principal operating cost. Formulas have been worked out, curves plotted, etc., to determine at what time in its life, a transformer should be economically junked. It is the purpose of this paper to present somewhat in detail some of the methods now in satisfactory use by operating companies.

The following data on maintenance of distribution transformers were obtained by means of questionnaires answered by and discussions held with several utilities in California and are fairly representative of present Pacific Coast practices.

Inspection, Test and Repair of Transformers

(1) Transformer Shop Practices—Practices among member companies differ widely on the proper procedure to follow when distribution transformers are removed from service. The rule in many cases is to put all transformers removed from service through the shop for general inspection, repair, cleaning, testing, replacing broken bushings, leads, etc. Most companies, however, inspect all transformers coming in and return to service without further attention those that appear to be in good condition.

TABLE I—Comparison of costs between factory made transformer leads and transformer cable.

	High Voltage				Low Voltage			
			Cost per lead				Cost per lead	
Kva.	Size	Inches	Factory	Cable	Size	Inches	Factory	Cable
1½–3	12	5/32	0.47	0.22	8	1/16	0.13	0.09
5–7½	12	5/32	0.49	0.23	6	1/16	0.16	0.12
10–15	12	5/32	0.49	0.23	2	1/16	0.35	0.25
25	10	5/32	0.57	0.34	1/0	5/64	0.50	0.37
37½	8	5/32	0.57	0.43	2/0	5/64		0.44
50	6	5/32		0.47	4/0	5/64		0.60

The filtering and testing of transformer oil is important and while it need not be done at regular short intervals, every three years, as recommended by some manufacturers, it should be done whenever the transformer is taken out of service for operating reasons unless the oil is known to be in good condition.

Some companies rewind transformer coils when burned out, while those companies not maintaining well equipped shops send the transformers to the manufacturer for repairs. If for any reason water has been allowed to enter the transformer, the coils and core should be thoroughly dried before putting back in service. A number of approved methods are in use, but the external heat method is generally used for distribution transformers. Care must be taken as a great deal of damage can be done by overheating the insulation.

(2) Maintenance Practices While in Service—Operating companies are agreed that distribution transformers should be inspected while in service once every two or three years to determine the condition of the oil, hangers, bushings and leads. Bushings often give trouble after being in service a few years, but usually can be replaced while the transformer is on the pole. Wiping about every two years is well worth the expense. Climatic, smoke and dust conditions determine the frequency of bushing wipings. Some of the older types of transformers have bushings which are too small, especially where systems have been cut from 2.3 to 4 kv. When the design of the transformer case does not permit the installation of a larger bushing, some companies have used lead-covered cable in place of the bushings. Leads can be replaced readily while the transformer is in service. Maintenance

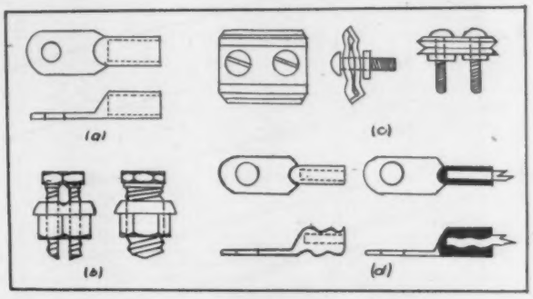


Fig. 1. Lugs and Solderless Connectors in Use.

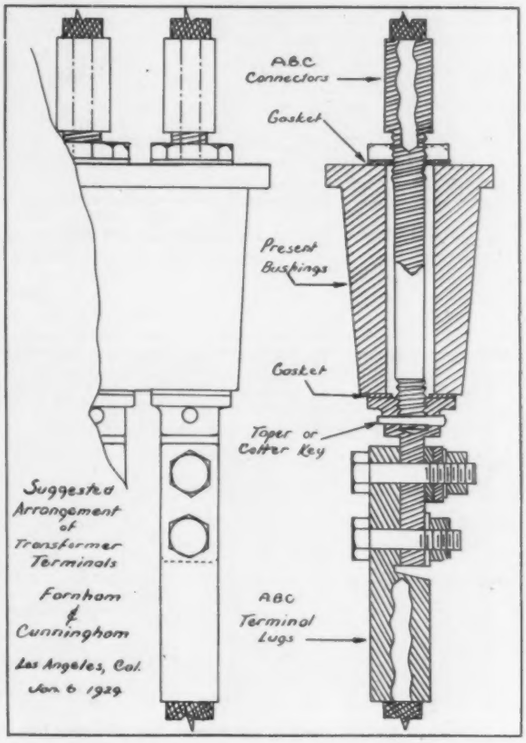


Fig. 2. Method of Attaching Solderless Connectors Directly to Transformer Bushings.

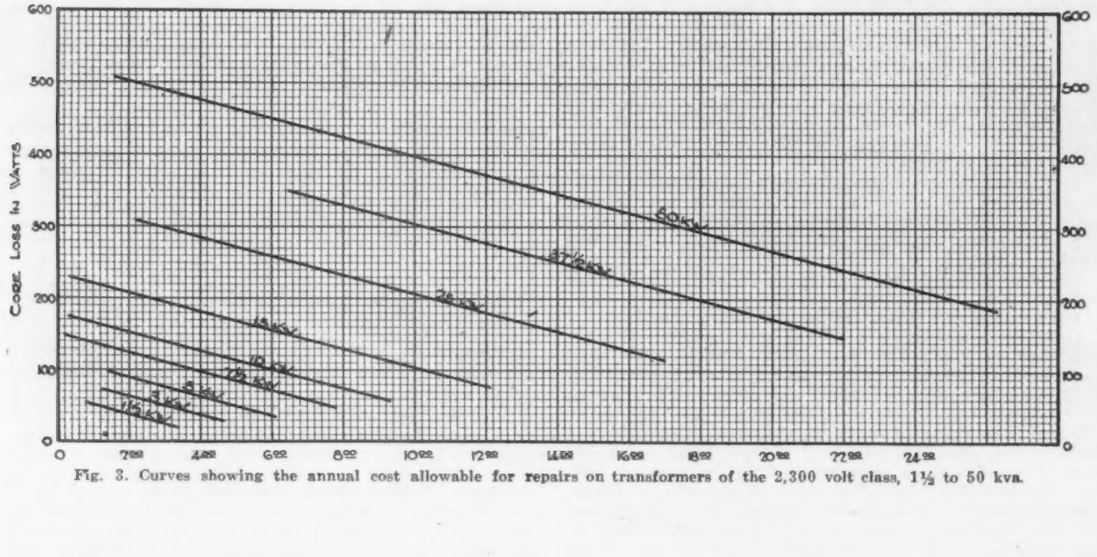


Fig. 3. Curves showing the annual cost allowable for repairs on transformers of the 2,300 volt class, 1½ to 50 kva.

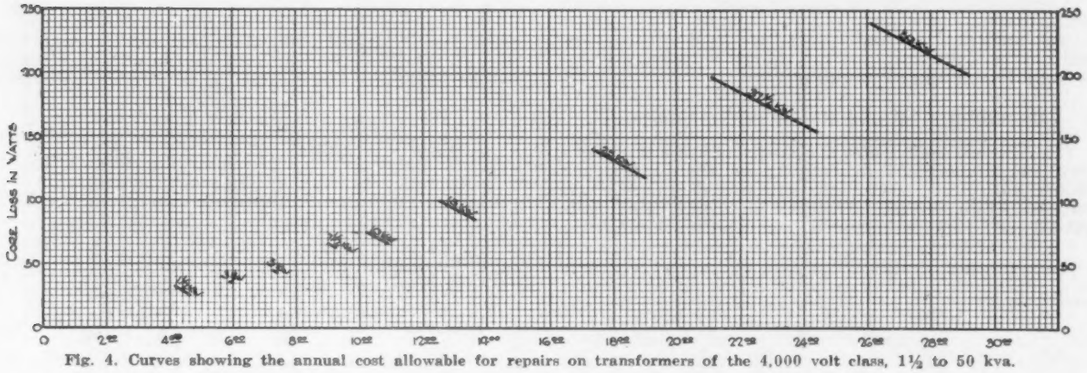


Fig. 4. Curves showing the annual cost allowable for repairs on transformers of the 4,000 volt class, 1½ to 50 kva.

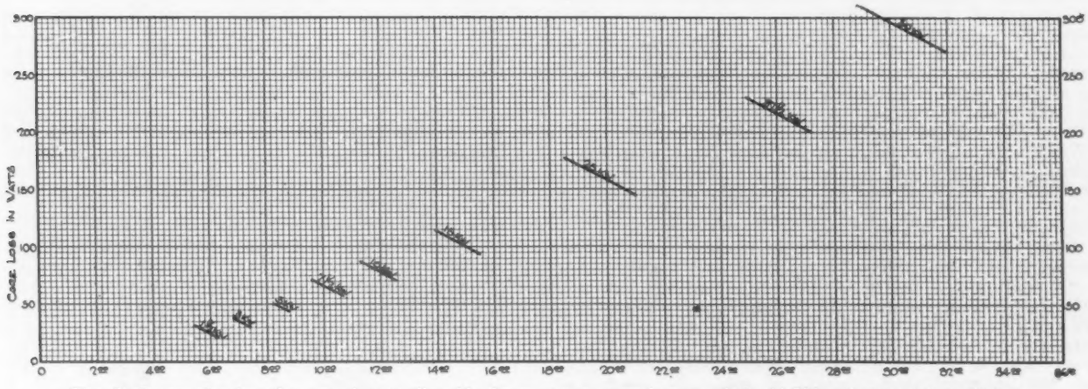


Fig. 5. Curves showing the annual cost allowable for repars on transformers of the 11,500-volt class, 2½ to 50 kva.

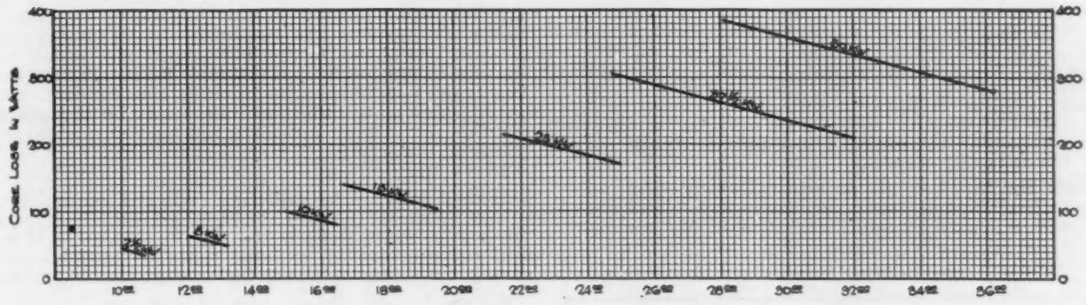


Fig. 6. Curves showing the annual cost allowable for repairs on transformers of the 11,500 volt class, 2½ to 50 kva.

ance of transformers while in service generally is done by special crews equipped to add oil if necessary and to make minor repairs on the job.

(3) Transformer Leads. The subject of transformer leads seems to be of great interest to operating companies, but they do not agree upon the best material to be used for replacing damaged leads. More companies appear to favor the use of transformer cable that of factory-made leads. First cost and the large assortment of factory-made leads necessary to keep in stock to meet demands are given as objections. Some companies, however, do not agree with these objections. Table I was made up from information obtained from one of the manufacturers and shows in a general way a cost comparison of the two materials for those sizes necessary to stock.

TABLE II—Manufacturers' numbers for 2,300-volt class.

GENERAL ELECTRIC COMPANY Transformer Serial No.	Year of Mfg.	WESTINGHOUSE CO. Transformer Serial No.
2073 - 3540	1888	--------
3541 - 14403	1889	--------
14404 - 29150	1890	--------
29151 - 41094	1891	--------
41095 - 55330	1892	--------
55331 - 63360	1893	--------
63361 - 70489	1894	--------
70490 - 82645	1895	--------
82646 - 93109	1896	78200 - 83799
93110 - 104636	1897	83800 - 88849
104637 - 119851	1898	88850 - 96699
119852 - 141172	1899	96700 - 103711
141173 - 166949	1900	103712 - 112099
166950 - 204734	1901	112100 - 117749
204735 - 214407	1902	117750 - 130799
241408 - 283870	1903	131800 - 140999
283871 - 319724	1904	141000 - 152099
319725 - 389739	1905	152100 - 163699
389740 - 487259	1906	163700 - 188999
487260 - 565649	1907	189000 - 209099
565650 - 618711	1908	209100 - 218799
618712 - 717241	1909	218800 - 235899
717242 - 829763	1910	235900 - 260899
829764 - 932100	1911	260900 - 287699
932101 - 1052034	1912	287700 - 319799
1052034 - 1311374	1913	319800 - 349799
1311375 - 1385802	1914	349800 - 379999
1385803 - 1478900	1915	380000 - 404399
1478901 - 1739466	1916	404400 - 435299
1739467 - 1924215	1917	435300 - 514457
1924216 - 2045370	1918	514458 - 526174
2045371 - 2230650	1919	526175 - 549169
2230651 - 2406249	1920	549170 - 604799
2406250 - 2569449	1921	604800 - 631693
2569450 - 2836549	1922	631694 - 674000
2836550 - 3025764	1923	674001 - 774799
3025765 - 3182498	1924	774800 - 1083499
3182499 - 3283599	1925	1083500 - 1236000
3283600 - 3938699	1926	1236001 - 1357000
3938700 -	1927	1357001 - 1470000

It may be seen that the cost of material is much greater on the primary factory leads and only slightly greater on the secondary than on the cable, but the cost of installation is much less on the factory-made leads in each case, so that the total cost differs only slightly. While that difference is in favor of the cable, a better job can be made, especially as regards oil siphoning, etc., with the factory-made leads. It also may be seen from the modified list of Table I that only four different sizes of high-voltage leads need be stocked for transformers up to and including 50 kva. Only six sizes need be stocked for the 115-230-volt secondaries and the same set can be used for the 230-460-volt class up to and including 25 kva. It may be noted that 11.5-kv. leads are used on all voltage classes from 2.3 kv. to and including 11.5 kv. While this procedure slightly increases the cost, it reduces the stock required and gives a larger factor of safety. If desired, the ⅛-in. insulation can be used for the 2.3 kv. class by adding three or four sizes to the stock.

(4) The Use of Lugs and Solderless Connectors— The use of lugs on transformer secondary leads is not standard among operating companies. Some put lugs on all transformers going through the shop while others go as far as to remove the lugs from new transformers before installing.

Solderless connectors have been used to some extent on transformer leads with satisfactory results. Figure 1 shows some of the lugs and solderless connectors now in use. Recommendations have been made to manufacturers to provide stationary lugs, fastened directly to the transformer bushings, doing away with the flexible leads. These recommendations have included the use of both the split soldered lug and the new type of solderless lug illustrated in Fig. 2. The suggestions have merit and it is hoped some manufacturer will experiment with that type of secondary lead and bushing connection.

TABLE III—Manufacturers' numbers for 4,000-volt class.

GENERAL ELECTRIC COMPANY Transformer Serial No.	Year of Mfg.	WESTINGHOUSE CO. Transformer Serial No.
1739467 - 1924215	1917	435300 - 514457
1924216 - 2045370	1918	514458 - 526174
2045371 - 2230650	1919	526175 - 549169
2230651 - 2406249	1920	549170 - 604799
2406250 - 2569449	1921	604800 - 631693
2569450 - 2836549	1922	631694 - 674000
2836550 - 3025764	1923	674001 - 774799
3025765 - 3182498	1924	774800 - 1083499
3182499 - 3283599	1925	1083500 - 1236000
3283600 - 3938699	1926	1236001 - 1357000
3938700 -	1927	1357001 - 1470000

The Use of Odd-Ratio Transformers

Keeping the odd-ratio transformer stock, such as the 11,000/120-240-volt rating, cleaned up has been a big problem with operating companies. Such transformers are fairly old and it is a question in many cases whether it pays to spend much money in correcting the ratio to make them of value at present day voltages. The problem has been partially solved in the following ways.

(1) By the Use of Auto-transformers—The auto-transformers are made for three-wire circuits and consist of an auto-winding and an auxiliary secondary winding. The auto-winding is connected from neutral to one "hot" leg and the auxiliary winding in the other "hot" leg, thus producing an equal boost or buck on both sides of a three-wire secondary. They can be mounted either on the crossarm or permanently attached to the transformer by means of special hangers. By using the latter method the auto-transformer can be connected in the shop thus obviating the use of a wrong transformer or an incorrect connection in the field.

TABLE IV—Manufacturers' numbers for 6,900-volt class.

GENERAL ELECTRIC COMPANY Transformer Serial No.	Year of Mfr.	WESTINGHOUSE CO. Transformer Serial No.
1739467 - 1924215	1917	435300 - 514457
1924216 - 2045370	1918	514458 - 526174
2045371 - 2230650	1919	526175 - 549169
2230651 - 2406249	1920	549170 - 604799
2406250 - 2569449	1921	604800 - 631693
2569450 - 2836549	1922	631694 - 674000
2836550 - 3025764	1923	674001 - 774799
3025765 - 3182498	1924	774800 - 1083499
3182499 - 3283599	1925	1083500 - 1236000
3283600 - 3938699	1926	1236001 - 1357000
3938700 -	1927	1357001 - 1470000

(2) By Cutting Out Turns on the Coils—Some companies have found it profitable to cut out the necessary number of turns from the low-voltage coils. This can be done at small expense if the shop is properly equipped.

Repair Versus Replacement of Transformers

Distribution transformers are used by operating companies in large numbers and many of them, having been in service a great many years, must be either repaired or junked. The proper time economically to junk a transformer is a problem that has been satisfactorily worked out by several operating companies in America and the methods used by two California companies will be outlined here.

TABLE V—Manufacturers' numbers for 11,500-volt class.

GENERAL ELECTRIC COMPANY Transformer Serial No.	Year of Mfg.	WESTINGHOUSE CO. Transformer Serial No.
1739467 - 1924215	1917	435300 - 514457
1924216 - 2045370	1918	514458 - 526174
2045371 - 2230650	1919	526175 - 549169
2230651 - 2406249	1920	549170 - 604799
2406250 - 2569449	1921	604800 - 631693
2569450 - 2836549	1922	631694 - 674000
2836550 - 3025764	1923	674001 - 774799
3025765 - 3182498	1924	774800 -1083499
3182499 - 3283599	1925	1083500 -1236000
3283600 - 3938699	1926	1236001 -1357000
3938700 -	1927	1357001 -1470000

The principal operating cost of a transformer is its core loss, an important factor in deciding the advisability of repairing and returning the transformer to service. Losses due to exciting current also should be included in the same class as core losses. The copper loss is of less importance as it is not constant like the core loss, but varies with the load. The following methods are being satisfactorily used to determine economic repair costs of transformers which have been removed from service.

Method No. 1—The following formulas can be used to determine the junking limits of a transformer both for loss in watts and per cent exciting current. If by test or otherwise it is found that the actual losses exceed the limits obtained, the transformer is junked.

Let Wl = watts junking limit to be found.
Let W_n = watts loss of new transformer.
Let Pl = per cent exciting current limit to be found.
Let P_n = per cent exciting current of new transformer.
Let C = cost of new transformer.
Let E = exchange value of old transformer.
Let R = cost of rewinding old transformer.
Let A = consumption cost per kw.-hr.
Let B = consumption cost per kva.-hr.
Let K = kva. capacity of transformer.

$$\frac{8{,}760 \times A \times Wl}{1{,}000} = 0.06(C - E) + \frac{8{,}760 \times A \times W_n}{1{,}000}$$

Therefore
$$Wl = \frac{0.0068\ (C\text{-}E)}{A} + W_n \qquad (1)$$

$$\frac{8{,}760 \times B \times Pl \times K}{100} = 0.06\ (C\text{-}E) + \frac{8{,}760 \times B \times P_n \times K}{100}$$

Therefore
$$Pl = \frac{0.00068\ (C\text{-}E)}{B \times K} + P_n \qquad (2)$$

The above formulas are for transformers that are not burned out. For burned out transformers, the same formulas hold true except that the cost of rewinding (R), is deducted from the net cost; i.e., (C-E) becomes (C-E-R). The transformer losses before being burned out must be known or an accurate estimate made of the probable losses. In the above formulas the value of 0.06 by which the net cost of the new transformer is multiplied was obtained by experience. In other words, experience has shown that it is good economy if the cost of the losses in an old transformer does not exceed the cost of the losses in a new transformer plus 0.06 times the net cost of a new transformer.

Method No. 2—The following test requirements were worked out several years ago by one operating company after a thorough investigation to determine when a distribution transformer should be junked. This method has been superseded, however, to a certain extent by Method No. 3. Some transformers can be junked under certain rules of this method without checking by Method No. 3. The necessary information on regulation, core loss and copper loss is obtained by test after the transformer has been removed from service. The so-called obsolete transformers are not removed from service solely for junking because of their inefficiency, but tests are made when they are removed in the normal course of operation.

Distribution transformers should be junked according to the following rules:

1. If the regulation is twice that of transformers now being purchased, generally using 80 per cent power factor.
2. If the core loss is three times that of transformers now being purchased.

TABLE VI. Operating Characteristics of General Electric Type "H" Distribution Transformers Manufactured Since 1896. For Operation on 2.3-kv., 60-Cycle Circuit. Core and Copper Loss.

All losses given below have been adjusted to a 2300 volt, 60 cycle basis, figured in accordance with present A. I. E. E. Rules

	Column #1		Column #2		Column #3		Column #4		Column #5		Column #6		Column #7		Column #8	
Kv-a	Core	Copper	Core	Copper	Core	Copper	Core	Copper	Core	Copper	Core	Copper	Core	Copper	Core	Copper
.6	28	16	28	15	24	15	18	15	15	20						
1	37	27	34	24	31	25	23	24	19	.32						
1.5	43	36	41	37	37	35	27	29	23	47	22	47	21	47	20	46
2	53	48	49	46	43	46	32	46	27	58						
2.5	55	57	53	50	47	53	35	58	30	72						
3	58	68	55	67	53	67	37	68	33	82	32	82	29	80	28	68
4	74	90	68	86	62	81	44	86	37	101						
5	78	106	83	92	70	107	47	98	42	123	40	108	38	108	36	108
7.5	117	156	105	126	98	147	61	140	57	170	54	151	51	150	48	148
10	139	186	135	151	121	175	81	166	73	207	64	193	62	191	57	190
15	184	271	183	222	155	248	111	273	95	298	88	263	83	263	77	263
20	220	327	207	294	180	290	136	340	118	376						
25	246	392	232	341	205	375	152	383	133	452	130	415	123	390	115	390
30	280	511	271	400	230	428	176	443	152	516						
37.5											175	570	164	557	148	515
40	336	640	322	537	293	565	217	548	191	640						
50	406	803	372	653	345	675	250	675	222	800	212	735	209	725	185	625

EXPLANATORY NOTES

Col. No. 1. Rating, 1,040-2,080/104-208 volts. Designs identified by form letters A, C, E, F and I. Furnished during period 1896-1903. Serial numbers approximately 82,600 to 250,000. We estimate that the core losses at the present time are not less than 25 per cent higher than the values shown in the above tables, due to aging of the steel.

Col. No. 2. These losses apply to transformers rated at 1,040-2,080/104-208 volts, representing the first designs having non-aging silicon steel cores. They are identified as form "G" transformers and were furnished during the period 1903-1907. Serial numbers approximately 250,000 to 500,000.

Col. No. 3. These losses apply to transformers rated 2,200/110-220 volts. The designs are identified as form "H", and were furnished during the period 1907-1908. Serial numbers, approximately 500,000 to 600,000.

Col. No. 4. These losses apply to transformers rated 2,200/110-220 volts. Designs are identified as form "H", represent greatly improved silicon steel and were furnished during the period 1908-1910. Serial numbers approximately 600,000 to 750,000.

Col. No. 5. These losses apply to transformers rated 2,400/120-240 volts. Designs are identified as form "K" and were furnished during the period 1910-1911. Serial numbers approximately 750,000 to 860,000.

Col. No. 6. These losses apply to transformers rated 2,200/110-220, 2,300/115-230, and 2,400/120-240 volts. Designs are identified as form "K" and "N" and were furnished during the period from 1911 to Oct., 1922. Serial numbers approximately 860,000 to 2,730,000.

Col. No. 7. These losses apply to forms "K", and "N", furnished during the period from Oct., 1922, to Feb., 1928. Serial numbers approximately 2,730,000 to 4,000,000.

Col. No. 8. Present guaranteed losses applying to transformers furnished subsequent to Feb., 1928. Serial numbers approximately from 4,000,000 and up.

3. If the sum of the core loss of the old transformers and the difference betweeen the copper loss of the old transformers and the copper loss of transformers now being purchased, is equal to or greater than three times the core loss of the transformers now being purchased.

4. If the cost of repairs to transformers built prior to 1907 exceeds 20 per cent of the cost of transformers of the same capacity and voltage now being purchased.

Method No. 3—The October 11, 1927 number of Power contained an article on Repair Versus Replacement of Old Transformers by Maurice D. Smith. The method outlined by Mr. Smith was used as a basis for a method now in use by a Western public utility to determine whether it is more economical to repair an old transformer or replace it with a new one.

In making an economic study of the transformer repair problem, the following items must be considered:

1. Cost of new transformer.
2. Junk value of old transformer.
3. Operating cost.
4. Annual fixed overhead cost.
5. Allowable annual cost of repairs.

The allowable repair cost of the transformer in question can be obtained from the curves (Figs. 3 to 6 incl.) which were plotted from known values of core losses obtained from the manufacturer (see Tables VI

TABLE VII. Operating Characteristics of General Electric Type "H" Distribution Transformers Manufactured Since 1923. For Operation on 4-kv. Circuits. Core and Copper Loss.

H-60-( )- 4000-115/230

	Column #1		Column #2		Column #3		Column #4		Column #5	
Kv-a	Core	Copper	Core	Copper	Core	Copper	Core	Copper	Core	Copper
1-1/2	32	43	31	42	26	46	26	45	26	45
3	36	81	35	79	35	81	35	79	35	79
5	45	130	43	130	45	136	43	134	43	134
7-1/2	66	170	66	164	66	166	63	158	63	158
10	75	198	70	193	72	193	66	188	66	188
15	100	287	90	275	93	280	85	270	85	270
25	140	440	128	410	128	410	118	410	118	410
37-1/2	197	600	185	640	185	640	174	625	154	580
50	240	730	240	685	235	690	212	690	200	680

EXPLANATORY NOTES

Col. No. 1. These transformers were furnished during the period from May, 1923, to October, 1925. No taps. Serial numbers approximately 2,800,000 to 3,460,000.

Col. No. 2. These transformers furnished during the period from October, 1925, to June, 1926. No taps. Serial numbers approximately 3,460,000 to 3,750,000.

Col. No. 3. These transformers furnished during the period from June, 1926, to February, 1927. Taps for 3,600 and 3,860 volts. Serial numbers approximately 3,750,000 to 3,900,000.

Col. No. 4. These transformers furnished during the period from February, 1927, to March, 1928. Taps for 3,600 and 3,800 volts. Serial numbers approximately 3,900,000 to 4,100,000.

Col. No. 5. These transformers furnished during the period from March, 1928, to date. Serial numbers approximately from 4,100,000 up.

to IX inclusive) as ordinates and values of allowable repair costs obtained from the following formulas, as abscissas.

Let A = Annual overhead cost of new transformer.
Let A_o = Annual overhead cost of old transformer.
Let B = Annual operating cost of new transformer.
Let B_o = Annual operating cost of old transformer.
Let C = Total annual cost of new transformer.
Let C_o = Total annual cost of old transformer.
Let D = Purchase cost of new transformer.
Let D_o = Junk value of old transformer.
Let K = Consumption cost per kw.-hr.
Let W = Core loss in watts of new transformer.
Let W_o = Core loss in watts of old transformer.
Let R = Allowable annual repair cost.

$$A = 0.12 \times D \quad (0.12 \text{ represents return on investment depreciation, etc.}) \tag{3}$$

$$B = \frac{W \times K \times 8{,}760}{1{,}000} \tag{4}$$

$$C = A + B \tag{5}$$

$$A_o = 0.12 \times D_o \tag{6}$$

$$B_o = \frac{W_o \times K \times 8{,}760}{1{,}000} \tag{7}$$

$$C_o = A_o + B_o \tag{8}$$

$$R = C - C_o \tag{9}$$

The above formulas were used to calculate three or four points for each of the curves of Figs. 3 to 6 inclusive. A curve was plotted for each capacity transformer of each voltage class. These curves should not be used in actual practice for junking transformers as they were plotted from data, rates, etc., which probably will not apply to the conditions of all companies.

Interpretation of Curves and Tables

The following are instructions for determining whether to repair or junk a transformer from the curves shown in Figs. 3 to 6 inclusive:

(1) Obtain the manufacturer's serial number from the name plate on the transformer. Then refer to Tables II to V inclusive, depending upon the voltage rating and determine the year that the transformer was manufactured. In order to use the data in Tables VI to IX inclusive for Westinghouse transformers, it will be necessary to find from Tables II to V inclusive the serial number of the General Electric transformer which corresponds to the serial number of the Westinghouse transformer of the same year. This serial number should be used thereafter for all further calculations.

(2) Consult Tables VI to IX inclusive. From the "notes" of this table determine the column where the serial number of the transformer in question belongs. Then refer to the proper column and obtain the core loss which corresponds to the size of the transformer.

(3) Refer to Figs. 3 to 6 inclusive. Using the core loss determined from Tables VI to IX inclusive, "the annual cost allowable for repairs in dollars" is found at the intersection of the ordinate (core loss) and the curve corresponding to the size of the transformer under investigation.

(4) (a) Estimate what the probable life of the transformer will be after it is repaired. Due consid-

TABLE VIII. Operating Characteristics of General Electric Type "H" Distribution Transformers Manufactured Since 1918. For Operation on 6.9-kv., 60-cycle Circuits. Core and Copper Loss.

H-60-( )-6900/11950Y-115/230

	Column #1		Column #2		Column #3		Column #4		Column #5	
Kv-a	Core	Copper	Core	Copper	Core	Copper	Core	Copper	Core	Copper
1-1/2	31	43	28	42	28	42	26	42	21	47
3	36	91	38	85	38	85	37	85	30	85
5	50	136	49	140	49	140	45	140	44	130
7-1/2	69	179	71	180	71	175	69	175	57	175
10	87	219	86	220	81	220	76	220	71	220
15	114	315	113	321	106	320	100	320	94	290
25	171	465	177	464	158	464	150	464	145	417
37-1/2	230	581	230	593	208	595	200	595	205	550
50	310	775	310	775	280	785	270	770	275	685

EXPLANATORY NOTES

Col. No. 1—These transformers furnished during the period from June, 1918, to May, 1923. Serial numbers approximately 1,974,000 to 2,800,000.

Col. No. 2. These transformers furnished during the period from May, 1923, to June, 1925. Serial numbers approximately 2,800,000 to 3,350,000.

Col. No. 3. These transformers furnished during the period from June, 1925, to Feb., 1927. Serial numbers approximately 3,350,000 to 3,900,000.

Col. No. 4. These transformers furnished during the period from Feb., 1927, to July, 1927. Serial numbers approximately 3,900,000 to 4,000,000.

Col. No. 5. These transformers furnished during the period from July, 1927, to date. Serial numbers approximately 4,000,000 up.

TABLE IX. Operating Characteristics of General Electric Type "H" Distribution Transformers Manufactured Since 1918. For Operation on 11.5-kv., 60-cycle Circuits. Core and Copper Loss.

H - 60 ( ) - 11500 - 115/230

	Column #1		Column #2		Column #3		Column #4	
Kv-a	Core	Copper	Core	Copper	Core	Copper	Core	Copper
2-1/2	44	73	39	76	39	76	34	75
5	64	127	57	128	54	128	48	130
10	100	225	81	212	81	212	80	212
15	140	314	120	304	118	300	103	290
25	215	447	183	400	180	400	170	400
37-1/2	305	590	250	565	210	565	220	545
50	385	790	332	725	325	710	280	685

EXPLANATORY NOTES

Col. 1. These transformers furnished during the period from Jan., 1918, to June, 1925. Serial numbers approximately 1,924,000 to 3,350,000.

Col. No. 2. These transformers furnished during the period from June, 1925, to Feb., 1927. Serial numbers approximately 3,350,000 to 3,900,000.

Col. No. 3. These transformers furnished during the period from Feb., 1927, to May, 1927. Serial numbers approximately 3,900,000 to 3,950,000.

Col. No. 4. These transformers furnished during the period from May, 1927, to date. Serial numbers approximately 3,950,000 up.

eration should be given to the year of manufacture, the normal life of a transformer and the nature of the repairs.

(b) The probable future life in years multiplied by the annual cost allowable for repairs (found from Figs. 3 to 6 inclusive) will give the total allowable cost for repairs to the transformer. This "total allowable cost" in no case shall exceed the cost of a new transformer.

(c) Estimate the cost of making repairs to the transformer.

(d) If the estimated cost of making repairs is less than the allowable cost for repairs, then the transformer should be repaired; if the estimated cost of making repairs is more than the allowable cost of repairs, then the transformer should be junked.

Example

A Westinghouse 25-kva. 2,300/115-230-volt transformer is in need of repairs.

(1) Consulting the name plate the serial number is found to be 550,110. Referring to Table II the transformer was found to be manufactured in 1920 and that the corresponding General Electric serial number is between 2,230,651 and 2,406,249.

(2) Consulting Table VI under "notes" it is found that this serial number is included under column No. 6. The core loss for a 25-kva. transformer of column No. 6 is 130 watts.

(3) Referring to Fig. 3, the annual cost allowable for repairs for a 25-kva. transformer with 130 watts core loss is $15.80.

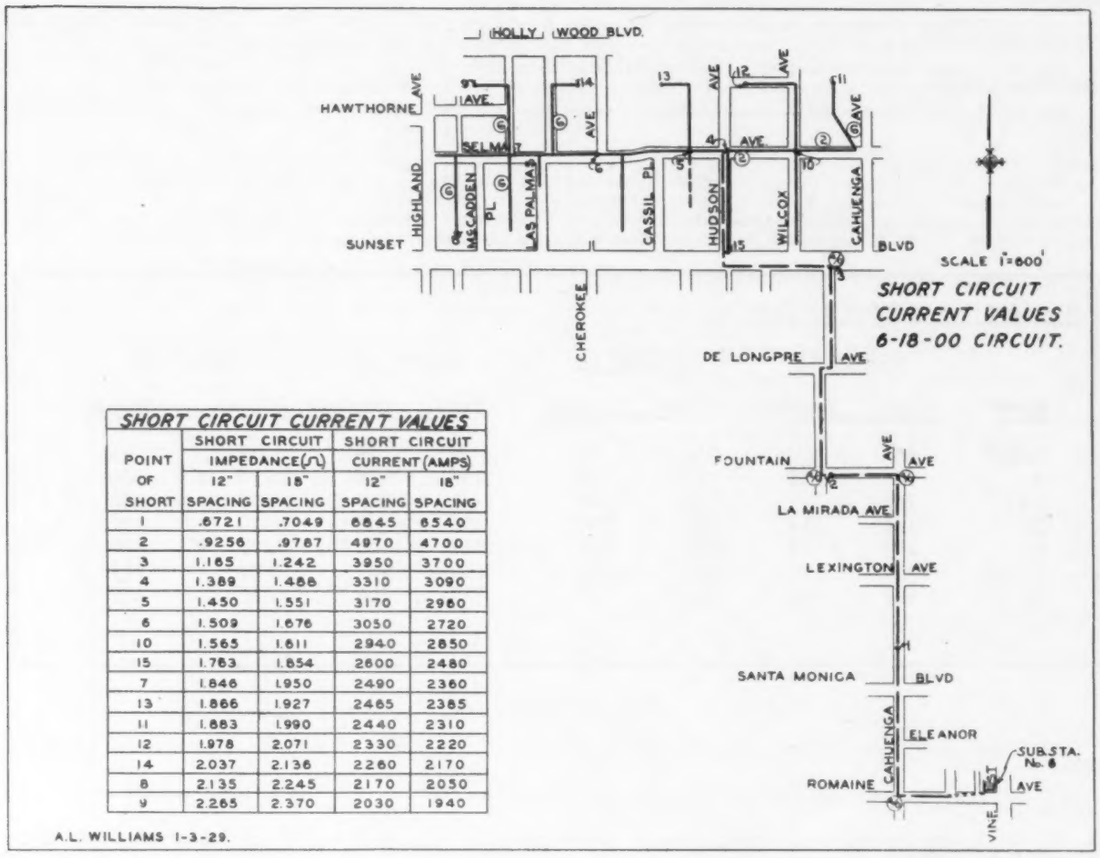
(4) (a) Considering that this transformer was manufactured in 1920 and considering the nature of the repairs, the future life of the transformer is estimated to be ten years.

(b) The total allowable repairs will be ten years at $15.80 or $158.00.

(c) The estimated cost of making repairs is $100.00.

(d) The transformer should be repaired because the estimated cost of repairs is less than the total allowable cost for repairs.

It may be seen from the foregoing example that after the curves have been worked up and plotted, any employee in the shop can use them to determine whether to repair or to junk any transformer. The only items to be determined from experience are the cost of repairs and the future life of the transformer. While the curves do not represent an absolutely correct solution of the repair problem, they give the most economical results in the easiest way of any method yet devised.



SHORT CIRCUIT CURRENT VALUES

POINT OF SHORT	SHORT CIRCUIT IMPEDANCE (Ω) 12" SPACING	18" SPACING	SHORT CIRCUIT CURRENT (AMPS) 12" SPACING	18" SPACING
1	.6721	.7049	6845	6540
2	.9256	.9787	4970	4700
3	1.165	1.242	3950	3700
4	1.389	1.488	3310	3090
5	1.450	1.551	3170	2980
6	1.509	1.676	3050	2720
10	1.565	1.611	2940	2850
15	1.763	1.854	2600	2480
7	1.846	1.950	2490	2360
13	1.866	1.927	2465	2385
11	1.883	1.990	2440	2310
12	1.978	2.071	2330	2220
14	2.037	2.136	2260	2170
8	2.135	2.245	2170	2050
9	2.265	2.370	2030	1940

A.L. WILLIAMS 1-3-29.

Fig. 1. Data and details of short-circuit current study between substations No. 6 and 18 of the Los Angeles Bureau of Power and Light.

Conductor Spacing*

IN THE early operation of overhead electric distribution systems, 2.3-kv. delta and 4-kv. star 11-in. horizontal pin spacing was adopted as standard practice by most of the power companies of California. The horizontal pin spacing for higher voltages of the utilities varied from 16-in. for 11-kv. construction to 48-in. for 60-kv. construction. In some instances the spacing varied depending upon the length of spans and the opinions of different engineers. The increasing use of electric energy developed heavy loads in congested areas. Long transmission lines to carry power from the hydro developments to centers of distribution were constructed and extensions to serve suburban communities were made. Service became an important factor making it necessary to adopt a better type of construction to avoid line failures and to permit safe working conditions for linemen, particularly as it became necessary to work primary lines of the lower voltages "hot" to avoid taking them out of service.

Laws were enacted by the State Legislature and orders issued by the Railroad Commission of the State of California setting forth space requirements and clearances, both horizontal and vertical. These developments brought about improvements in the type of overhead line construction and the adoption of new standards.

As lines were extended into the valleys, along the coast, and into the mountains all kinds of weather conditions were met. Greater span lengths were adopted by some companies in view of economy. The use of steel structures also brought about longer lengths of spans. Interruptions to service due to line failures caused investigations to be made with the result that greater horizontal and vertical spacing was found necessary to avoid lines blowing together during severe wind storms, or swinging together due to line surges or snow unloading on lines carried in a vertical plane. Lines frequently swung together and shorted when poles were struck by automobiles. If workmen were at all careless where restricted spacing was in use, the lines occasionally were shorted.

One utility reports that during a storm in February, 1927, a check was made of line failures showing that:

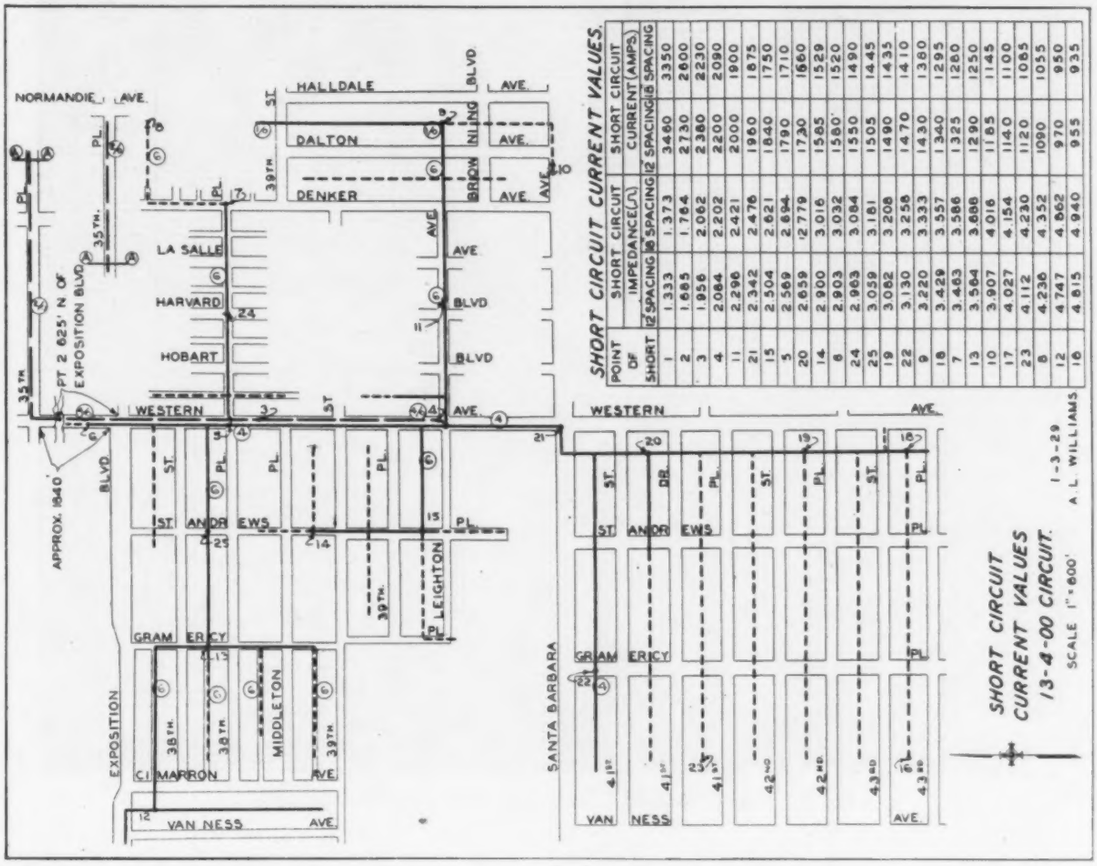
65 per cent were on 12-in. horizontal spacing with poles spaced 160 ft. or less.

32 per cent were on 12-in. horizontal spacing with poles spaced 160 ft. or more.

3 per cent were on 18-in. horizontal spacing with poles spaced 160 ft. or less.

In 9.5 per cent of the failures, regardless of the cause, one or more occurred at other locations due to line surges. Based upon this study the utility adopted

* Part IV of report of pole line structures, devices and maintenance subcommittee of overhead systems committee, Engineering Section. Committee list given on a preceding page together with Part I of this report.



POINT OF SHORT	SHORT CIRCUIT IMPEDANCE (Ω) 12" SPACING	16" SPACING	SHORT CIRCUIT CURRENT (AMPS.) 12" SPACING	16" SPACING
1	1.333	1.373	3460	3350
2	1.665	1.784	2730	2600
3	1.956	2.062	2380	2230
4	2.064	2.202	2200	2090
11	2.296	2.421	2000	1900
21	2.342	2.476	1960	1875
15	2.504	2.621	1840	1750
5	2.569	2.694	1790	1710
20	2.659	2.779	1730	1660
14	2.900	3.016	1585	1529
6	2.903	3.032	1580	1520
24	2.963	3.084	1550	1490
25	3.059	3.181	1505	1445
19	3.082	3.208	1490	1435
22	3.130	3.258	1470	1410
9	3.220	3.333	1430	1380
18	3.429	3.557	1340	1295
7	3.463	3.586	1325	1260
13	3.584	3.886	1290	1250
10	3.907	4.016	1185	1145
17	4.027	4.154	1140	1100
23	4.112	4.230	1120	1085
8	4.236	4.352	1090	1055
12	4.747	4.862	970	950
16	4.815	4.940	955	935

Fig. 2. Data and details of short-circuit current study between substations Nos. 13 and 4 of the Los Angeles Bureau of Power and Light.

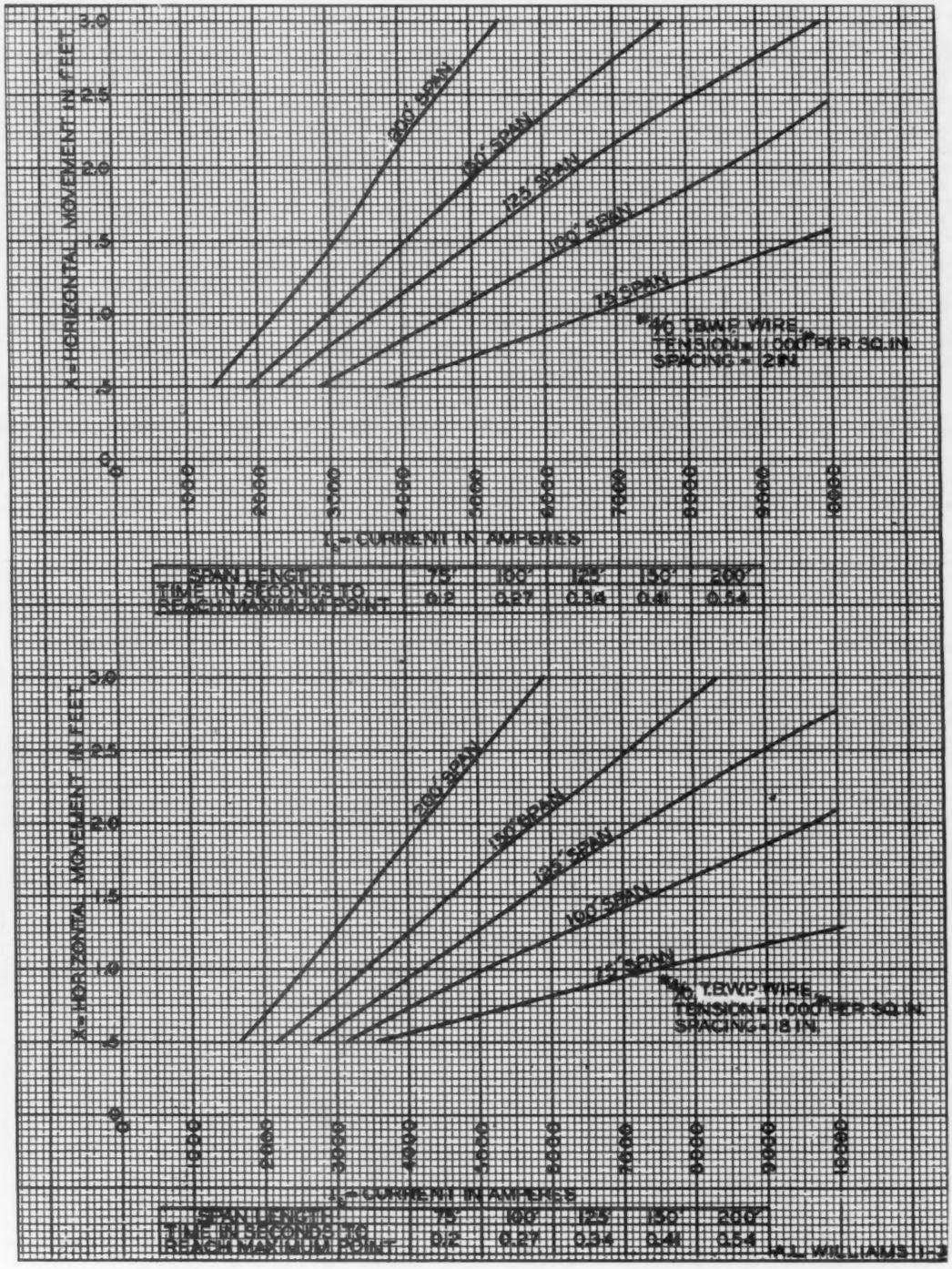


Fig. 3. Horizontal movement of conductors under short-circuit conditions.

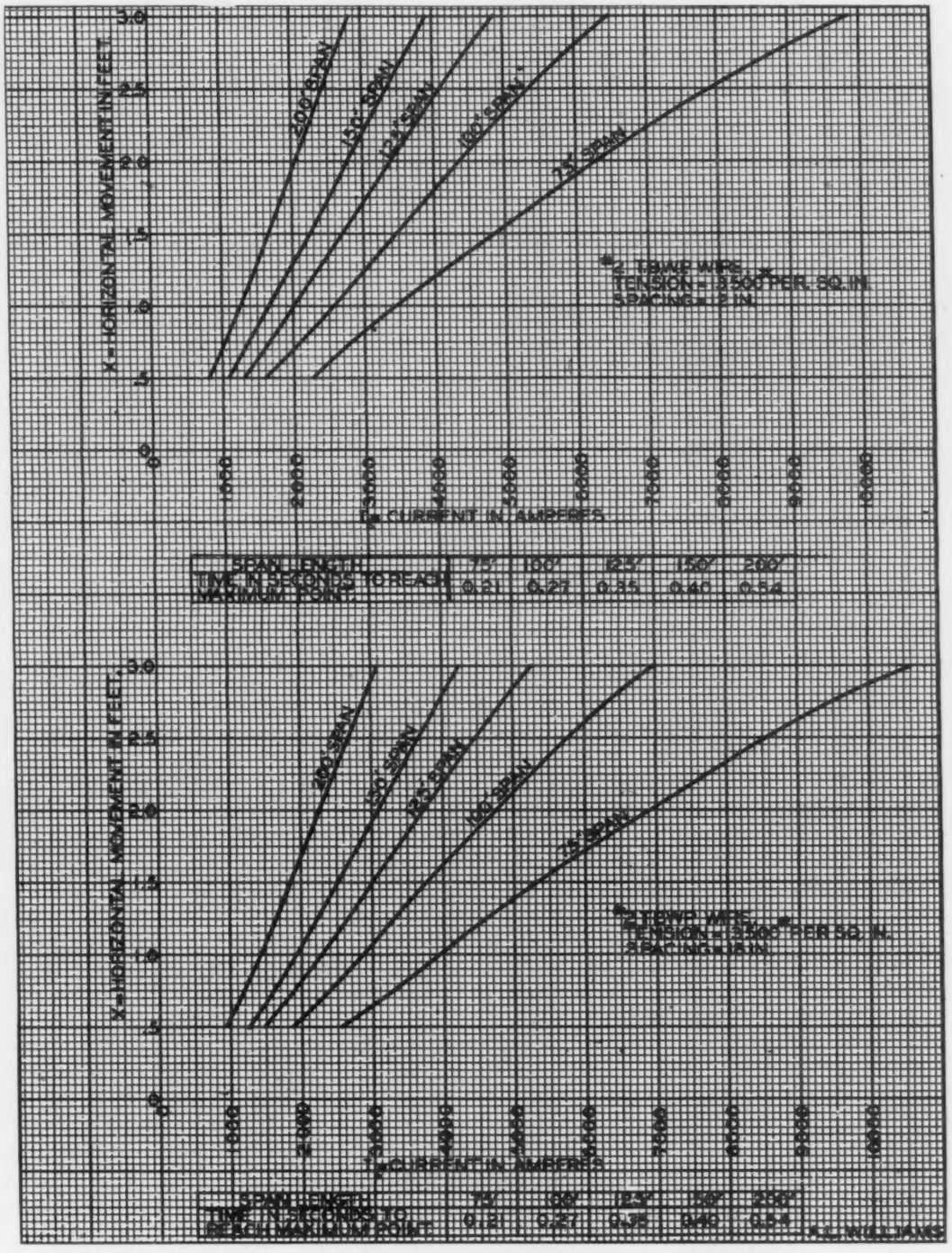


Fig. 4. Horizontal movement of conductors under short-circuit conditions.

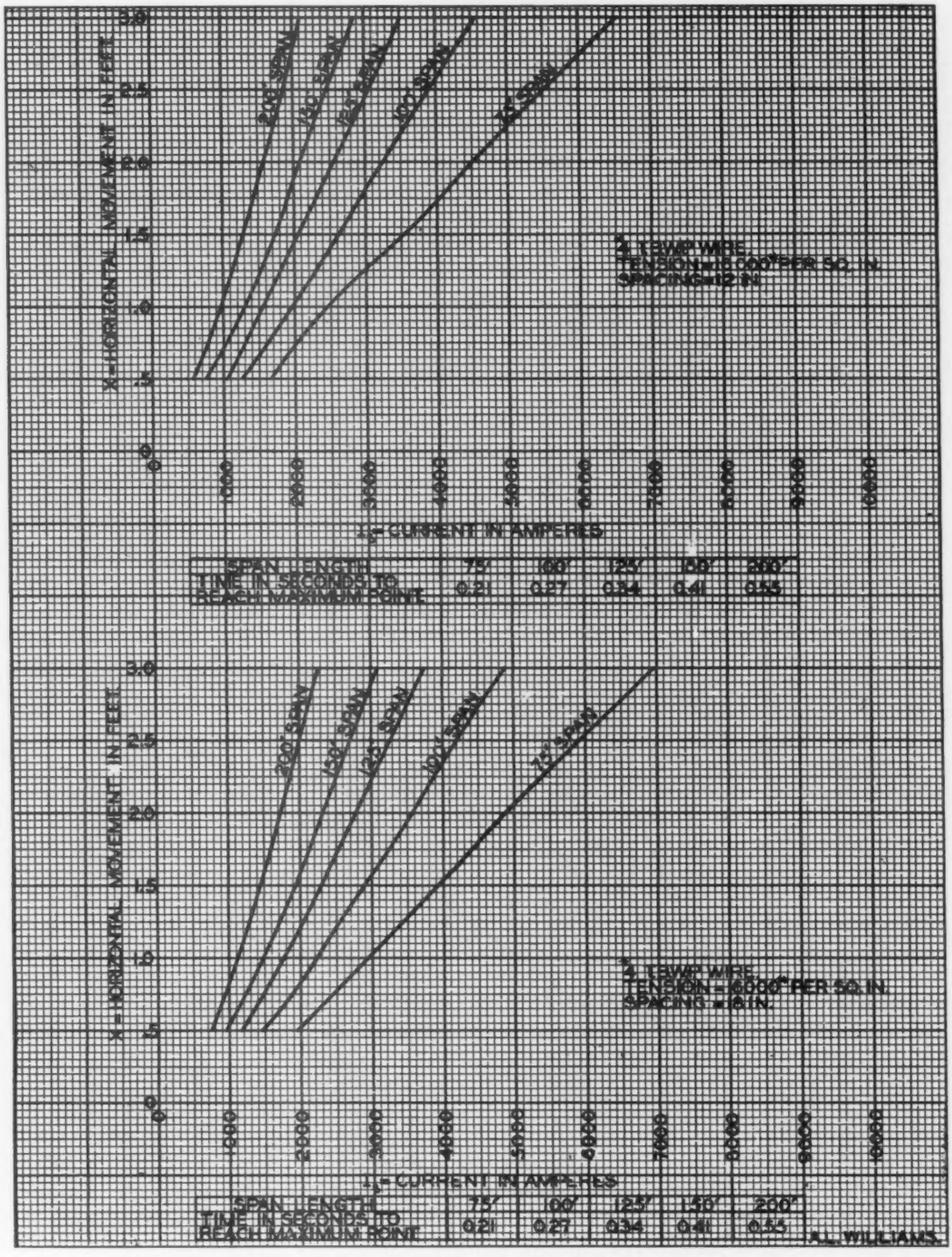


Fig. 5. Horizontal movement of conductors under short-circuit conditions.

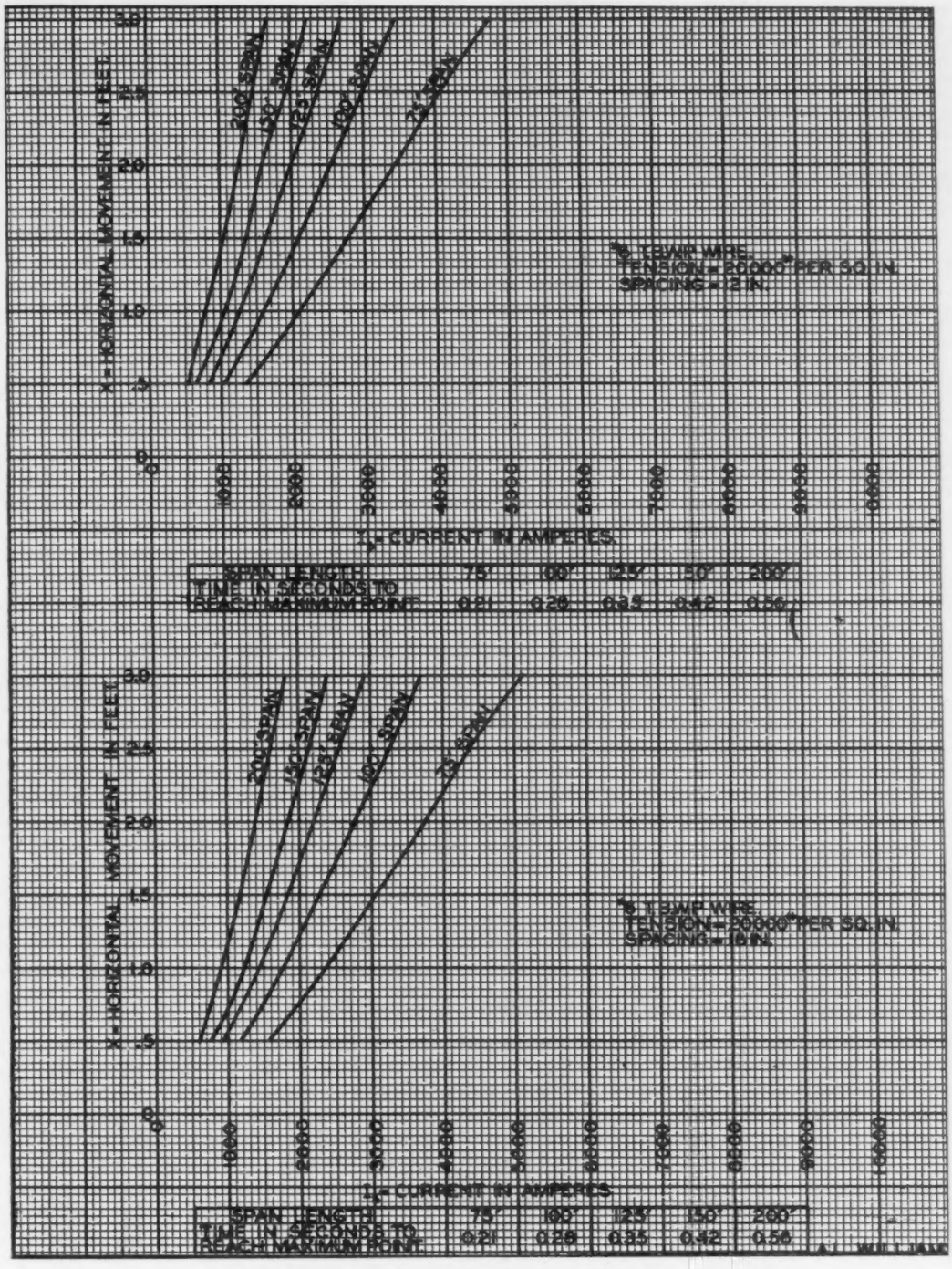


Fig. 6. Horizontal movement of conductors under short-circuit conditions.

a standard horizontal pin spacing of 18 in. on all its 4.6-kv. circuits. A record has been kept and investigation made of primary failures since March, 1927, and it may be of interest to compare the periods of March to December, 1927, with the corresponding period in 1928. It should be remembered that during these periods re-spacing was in progress and that weather conditions from year to year are not the same. Furthermore, the period covered does not include the winter months of December to March. Results show that the wider spacing has been of considerable benefit in improving service.

Cause of Failure	Reduction In Number of Failures 1928 compared to 1927
Wind	84 per cent
Surge	38 per cent
Other causes	40 per cent

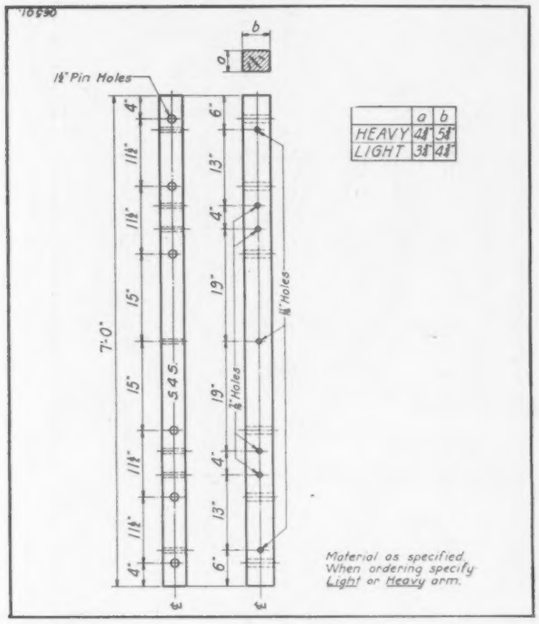


Fig. 7. Design details of 7-ft., 6-pin light and heavy crossarms.

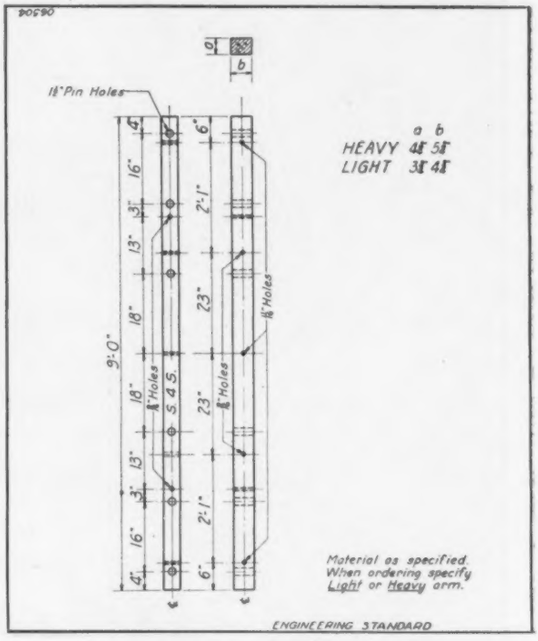


Fig. 9. Details of 9-ft., 6-pin light and heavy crossarms with 17-kv. pole clearance.

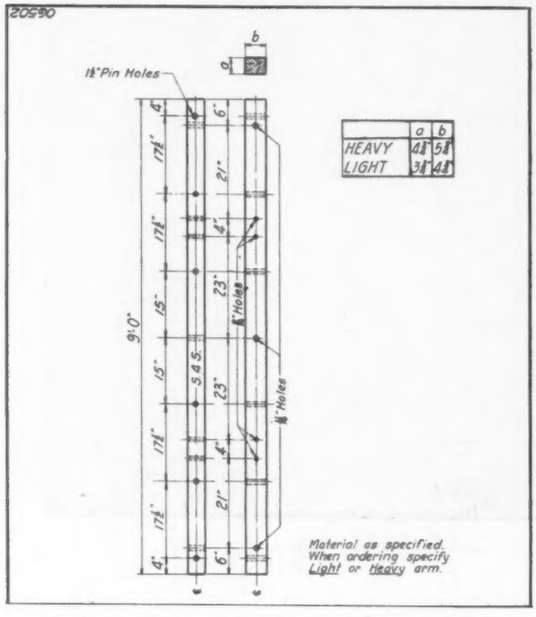


Fig. 8. Details of 9-ft., 6-pin light and heavy crossarms with 4-kv. clearance.

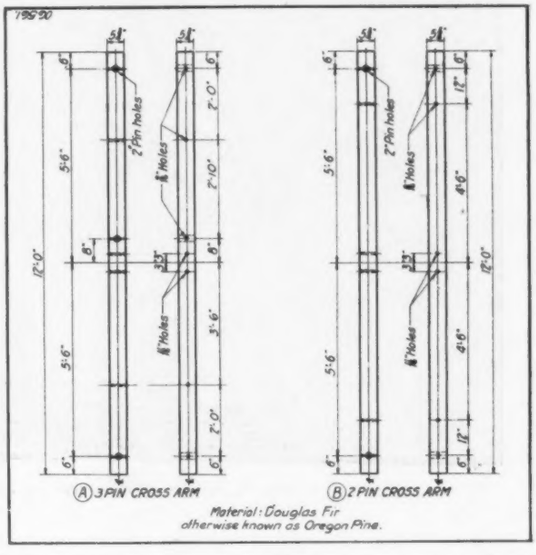


Fig. 10. Details of 12-ft., 2-and 3-pin crossarms for 60-kv., single-arm construction.

Of the cases of wind and surge, 7.5 per cent were on 18-in. horizontal pin spacing and 92.5 per cent on 12-in. spacing. The total number of failures in 1928 showed a 37 per cent decrease as compared with the corresponding period in 1927. This reduction is in part due to a more generous use of tree wire as well as greater pin spacing.

The comparatively smaller reduction of surge failures than those due to wind led to a theoretical study of this phase of the trouble. Curves were plotted showing the relation between horizontal conductor movement, short-circuit current and span length for various sizes of triple braid weatherproof wire at 12 and 18-in. spacing. The wire tension used in the computations was that resulting from 18-in. sag on a 150-ft. span under light loading conditions as defined by General Order No. 64A

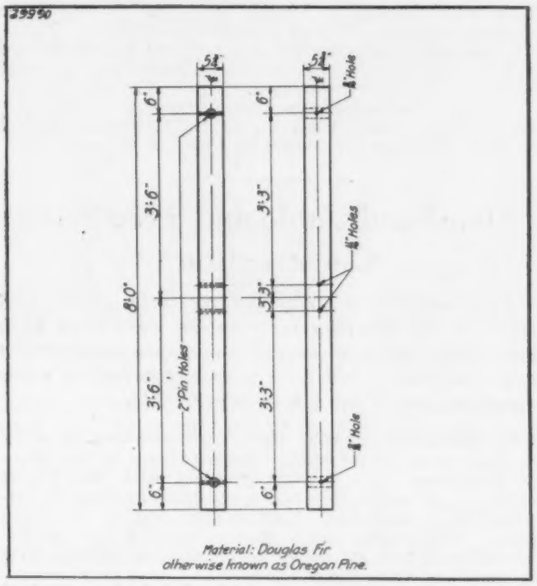


Fig. 11. Details of 8-ft., 2-pin crossarm for 60-kv. single-arm construction.

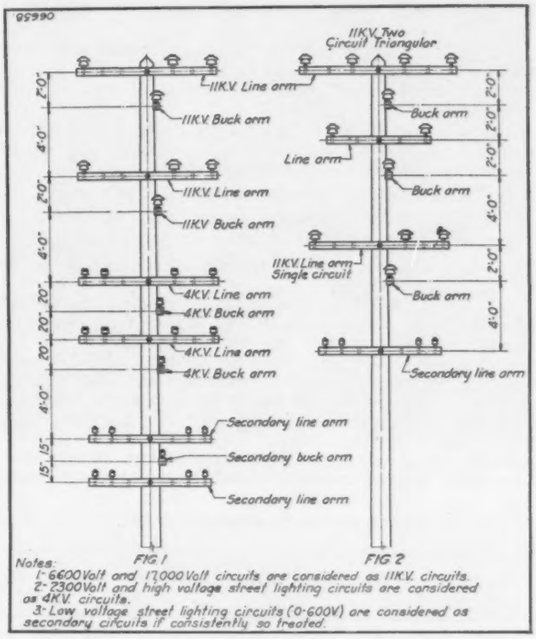

95990
11KV Two Circuit Triangular
11KV Line arm
11KV Buck arm
Line arm
Buck arm
11KV Line arm
11KV Buck arm
11KV Line arm Single circuit
4KV Line arm
4KV Buck arm
4KV Line arm
4KV Buck arm
Secondary line arm
Secondary buck arm
Secondary line arm
Buck arm
Buck arm
Buck arm
Secondary line arm
FIG. 1
FIG. 2
Notes:
1- 6600 Volt and 17,000 Volt circuits are considered as 11KV. circuits.
2- 2300 Volt and high voltage street lighting circuits are considered as 4KV. circuits.
3- Low voltage street lighting circuits (0-600V) are considered as secondary circuits if consistently so treated.

Fig. 13. Vertical separation between line and buck arm for distribution circuits.

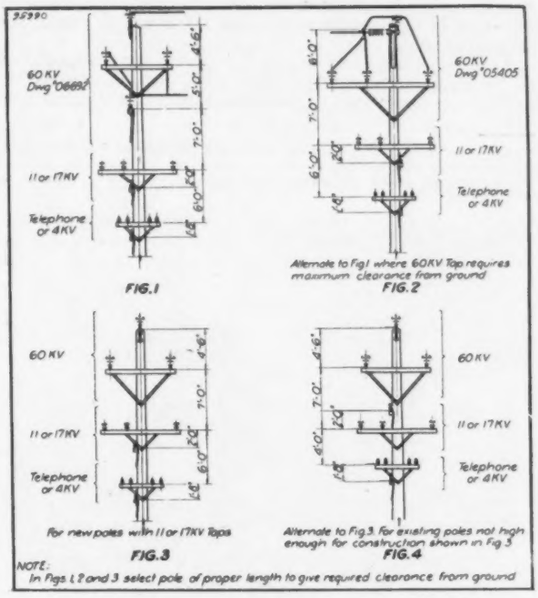

95990
60 KV Dwg "06692"
11 or 17KV
Telephone or 4KV
FIG. 1
60KV Dwg "05405"
11 or 17KV
Telephone or 4KV
Alternate to Fig. 1 where 60KV Top requires maximum clearance from ground
FIG. 2
60 KV
11 or 17KV
Telephone or 4KV
For new poles with 11 or 17KV Tops
FIG. 3
60 KV
11 or 17KV
Telephone or 4KV
Alternate to Fig. 3 for existing poles not high enough for construction shown in Fig. 3
FIG. 4
NOTE:
In Figs. 1, 2 and 3 select pole of proper length to give required clearance from ground

Fig. 12. Vertical separation of line buck arms for 60-kv., distribution, and telephone circuits.

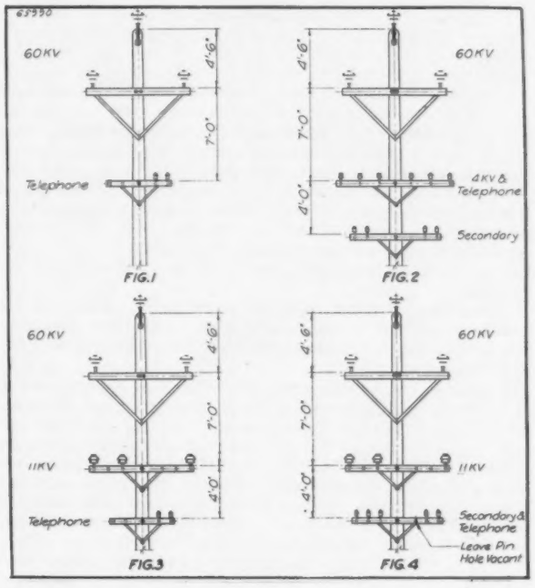


Fig. 14. Vertical separation of line arms for 60-kv., distribution, and telephone circuits.

of the Railroad Commission. The curves were computed from formulae developed by engineers of the utility.

In general the curves indicate the following:

(1) For the same values of short-circuit current the movement at 18-in. spacing is from 16 to 20 per cent less than at 12-in. spacing, the per cent of reduction being greater with the smaller wire sizes. Of course the wider spacing adds further safety in that a larger conductor movement is required to give the same relative hazard.

(2) For the same current values movement decreases with wire size. This effect is somewhat offset by the greater short-circuit current values allowed by the larger conductors.

(3) Shortening the span length decreases the horizontal conductor movement for the same current values. Roughly, reducing the span length from

200 ft. to 150 ft. reduces swing by 34 per cent.

150 ft. to 125 feet reduces swing by 20 per cent.

125 ft. to 100 ft. reduces swing by 25 per cent.

An over-all reduction from 200 to 100 ft. reduces the swing by 65 per cent.

In order to make a more practical study of the effect of spacing on surge, a study was made of two existing circuits. Both circuits carry 300 amp. at 4.6 kv. with approximately one mile of No. 4/0 wire between the station and center of distribution. One circuit served a small area of heavy load density where a majority of the primary mains were No. 2 copper with some No. 6 branch lines. The station transformer capacity involved in a short-circuit was 15,000 kva. The other circuit covered about three or four times

TABLE I—Test circuit short-circuit data.

Span Length (Feet)	No. of Points Computed for Short-Circuit Current (Is)	Points where Short-Circuit Current (Is) Will Cause Failure 12-in Spacing No.	12-in Spacing Per Cent	18-in Spacing No.	18-in Spacing Per Cent	Failure Ratio 12 in to 18 in.
First Circuit						
100	15	7	47	0	0	
125	15	11	74	4	31	0.38
150	15	13	87	8	53	0.62
200	15	15	100	13	87	0.87
Second Circuit						
100	25	0	0	0	0	
125	25	2	8	0	0	
150	25	10	40	1	4	0.10
200	25	15	60	7	28	0.48

the area of the first circuit and the primary mains were No. 4 copper with No. 6 branch lines. The station transformer capacity involved in short-circuit was 5,000 kva.

Phase-to-phase short-circuit values were computed for various points on the primary systems, assuming a sustained voltage on the 33-kv. station bus. The values of short-circuit current ranged from 2,000 to 7,000 amp. for the first station and from 1,000 to 3,500 amp. on the second.

Assuming, for the sake of comparison, that a horizontal conductor movement of 6 in. more than the spacing will cause a failure, the following tabulations have been made.

Under the conditions assumed for the above tabulations it is apparent that 18-in. spacing should practically eliminate trouble from the smaller stations and on circuits covering large areas and should reduce by from 15 to 60 per cent the trouble on the circuits from larger stations, particularly if long spans are avoided. Under the general system conditions now prevailing it seems that while the wider spacing is not a complete remedy for surge failures, it does warrant the expense of making the change as rapidly as circumstances will permit.

It is pretty well agreed that a minimum horizontal pin spacing of 13 in. for 4-kv. lines, 16 in. for lines carrying 11 kv. and 17 kv., and 6 ft. for 60-kv. lines is safe practice providing the pole spans are not in excess of 150 ft., 175 ft., and 264 ft., respectively, for the above voltages and that the wire tension is sufficient to avoid excessive sag.

Horizontal wire spacing depends entirely upon local conditions such as length of spans, wind velocity, snow leading, etc. The Railroad Commission's General Order 64A requires certain minimum horizontal pin spacing and vertical clearances which warrant no further study except to comply with the order. It is obvious, however, that to meet local operating difficulties in many instances greater horizontal spacing and vertical clearance are essential. These features must be met by the engineers as they present themselves.

Typical horizontal pin spacing giving satisfactory service is shown in Figs. 7 to 11 inclusive and typical vertical spacings are shown in Figs. 12 to 14.

Overhead Cable and Tree Wire Construction*

This report is a study of the relative merits and costs of constructing distribution lines with high poles, overhead lead-covered cable, open construction with tree wire and tree wire supported in cable rings suspended on a messenger cable.

INTERFERENCE with electric distribution lines by shade trees along public thoroughfares in the State of California is a serious problem with the public utilities. A serviceable and economical method of construction is essential. Maintenance cost is a serious factor with many types of construction due to the necessity of tree trimming to clear open wiring, wire failures and cable failures.

Tree trimming beyond a specified height is prohibited by the Highway Commission of the State and in some instances by other governing bodies. There is an economical limit to the height of poles that can be set, and underground construction is prohibitive because of initial cost. Overhead cable construction has, in a measure, given satisfactory results, providing proper material is used, with particular reference to the grade of lead sheath.

Tree wire has been in use for many years and found to be quite satisfactory. The first cost is reasonable and its use involves a minimum of maintenance and

* Part V of report of pole line structures, devices and maintenance subcommittee of overhead systems committee, Engineering Section. Committee list given on a preceding page together with Part I of this report.

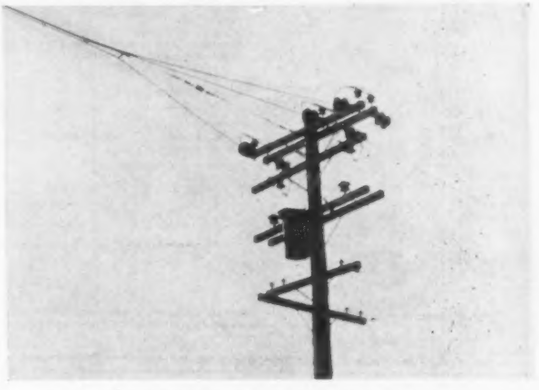


Fig. 1. Method of dead-ending lead-covered cables.

eliminates the necessity of high poles. One utility of the state has a 4-kv. line four miles in length in which there is 2½ miles of tree wire. There has not been a single interruption to service on this line during the six years of its existence. The following discussion on the different types of construction in use is gathered from what has been experienced by the utilities of the state.

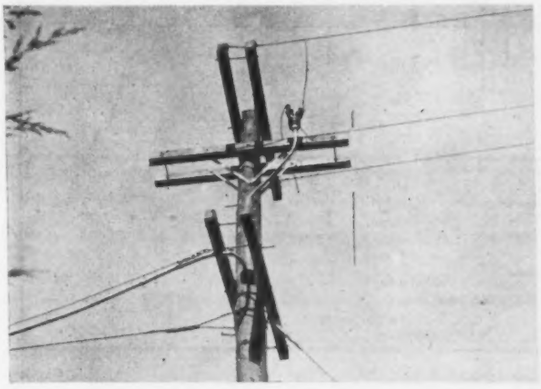


Fig. 2. Method of dead-ending tree wire supported in cable rings.

High Poles

This method of clearing trees is quite conspicuous along the highways and without question gives the greatest satisfaction providing it is not necessary to set poles of excessive height. Even this would not be objectionable on the part of the utility if it were assured that trees could be trimmed to a height not exceeding 40 ft. The cost covering this type of construction will be compared with other types later in the report.

Open Type Construction

This involves the stringing of special insulated wire, called tree wire, using flat-top construction. Due to its weight poles should not be set in spans exceeding 150 ft. The use of open construction gives satisfaction where the foliage is light and where wires can be kept from contacting heavy branches or limbs of the trees. A comparison of the cost of this type of construction also will be taken up later.

Overhead Construction Using Lead Covered Cable

It has been necessary upon occasions, due to heavy tree growth and the necessity of having to provide good service, to make extensions using two or three-conductor lead-covered cable. The cost of this type of construction is high, particularly in lightly loaded areas. It does, however, assure good service. The main difficulty in using lead-covered cable is the complications in making transformer connections and branch-line taps. Cable splicers are not always available resulting in a great deal of delay, particularly in case of cable failures. The installation of overhead cable necessitates its being suspended in cable rings supported on messenger cables. Ordinary underground lead-covered cable is not satisfactory as the lead sheath is too soft and soon is worn through in the rings. When using this type of construction the lead specifications should call for approximately 1 per cent antimony. The erection of lead-covered cable is not economical. It is heavy and requires weatherproof terminals wherever a tap is made. Pole spacing should not exceed 150 ft.

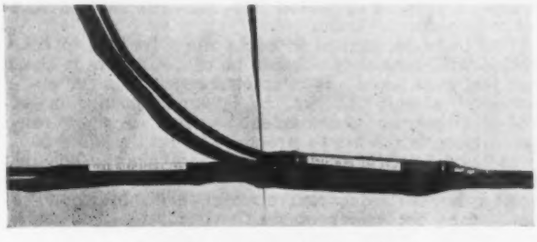


Fig. 3. Tree wire supported in cable rings.

Fig. 4. Tree wire tap and splice.

Tree Wire Suspended in Messenger

This type of construction has been given a trial in the East on 4-kv. circuits with apparently good results. It also has been tried in this state, but not long enough to assure success. The method used is to pull the wire through cable rings suspended on a messenger. (See Figs. 2 and 3.) Specially insulated wire is recommended and protective shields should be used with the cable rings. This type of construction does not call for terminals and therefore the making of taps is simplified. The wire is prevented from rubbing against the trees and falling limbs do little damage. A transformer installation is shown in accompanying illustrations.

Poles 35 or 40 ft. in length spaced 200 ft. apart give satisfactory results. The messenger should be ½-in. high-strength galvanized steel, depending of course upon the weight of the equipment to be carried. The messenger should be grounded every fourth pole. (See Fig. 5) The cable rings should be fitted with aluminum saddles to protect the insulation of wires from chafing. These rings give good results spaced 18 in. apart. In connection with rings it may be interesting to note that one Eastern company used Marlin twine in place of metal rings. Splicings for taps for transformer and other purposes are made practically the same as with any insulated wire. Care, however, must be taken in providing insulation equally as good as is used in the manufacture of the wire itself. To assure protection a fiber tube should be slipped over the tap, taped in place, and filled with cable compound.

When dead-ending, the tree wire should be attached to the messenger at least 5 ft. from the dead-end pole. The conductors should be tied to the messenger with Marlin twine at the point where the wires begin to fan

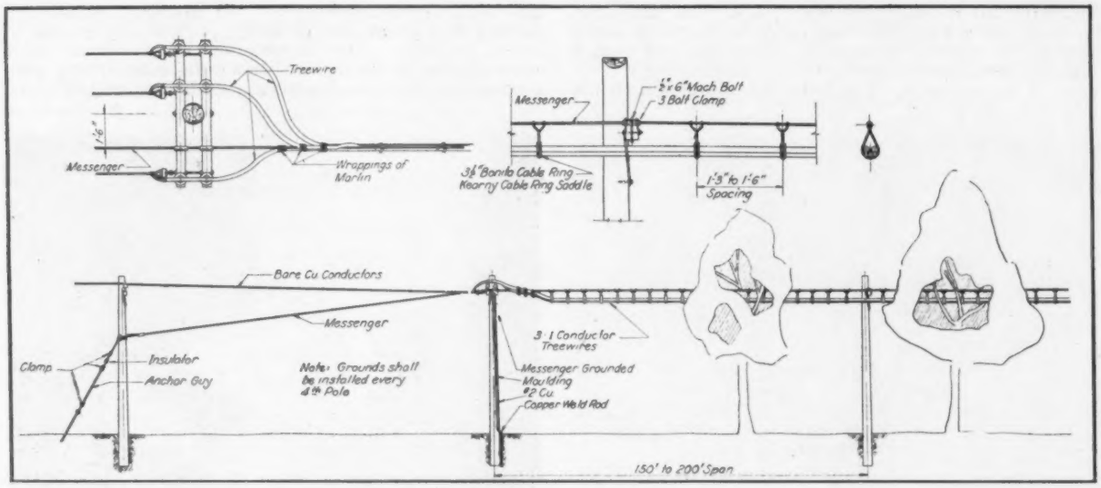


Fig. 5. Typical aerial tree-wire installation

TABLE I—Relative costs of various types of pole line construction to clear trees—No. 6 conductors.
(Cost per 1,000 feet of line, overhead charges included).

	Line Voltage—2,300/4,000 (Y) 3 Phase				Line Voltage—6,600/11,500 (Y) 3 Phase			
Height of Poles	W. P. Wire 150-ft. Spans	Tree Wire 3/32" Ins. Open Const. 150-ft. Spans	Tree Wire 9/64" Ins. Messenger Const. 200-ft. Spans	L. C. Cable —4,500 volt Messenger Const. 150-ft. Spans	B. C. Wire 250-ft. Spans	Tree Wire 6/32" Ins. Open Const. 150-ft. Spans	Tree Wire 8/32" Ins. Messenger Const. 200-ft. Spans	L. C. Cable —11,500 volt— Messenger Const. 150-ft. Spans
35	$350	$585	$1,200	$1,125	$210	$ 760	$1,910	$1,395
40	380	615	1,220	1,155	240	790	1,930	1,425
45	405	645	1,235	1,180	245	820	1,950	1,450
50	450	685	1,265	1,220	280	860	1,980	1,495
55	510	750	1,310		310	930	2,030	
60	560	795	1,340		340	970	2,060	
65	600	845			370	1,020		
70	675				420			
75	715				485			

TABLE II—Relative cost of replacing existing poles with higher poles and installing tree wire or L. C. Cable, No. 6 conductors.
(Cost per 1,000 feet of line, overhead charges included.)

	Cost of Setting Poles*			Cost of Installing Tree Wire on Existing Poles					
				Line Voltage 2300/4000 (Y) 3 Phase			Line Voltage 6600/11500 (Y) 3 Phase		
Height of Poles	150-ft. spans	200-ft. spans	250-ft. spans	Tree Wire Open Const.	Tree Wire Messenger Const.	L. C. Cable Messenger Const.	Tree Wire Open Const.	Tree Wire Messenger Const.	L. C. Cable Messenger Const.
40	$285	$210	$170	$350	$1,025	$890	$530	$1,740	$1,160
45	310	230	180						
50	350	255	210						
55	420	305	245						
60	465	335	275						
65	510	370	300						
70	585	425	350						
75	625	495	420						

*Includes cost of crossarms and transfer of wire to new poles.

out. They are then attached to insulators and connected to the open construction work in the usual manner. (See Figs. 2 and 5.)

Recommended Tree Wire Insulation

On open-work construction suspended on insulators the ordinary stock tree wire is satisfactory, that is, having 3/32-in. rubber insulation for star-connected circuits 2.3 kv. to ground, and 6/32-in. rubber insulation for star-connected circuits 6.9 kv. to ground. The insulation should be protected and covered by a layer of tape, a serving of tarred jute, a non-metallic armor and weatherproof braid.

Wire to be suspended in cable rings for use in connection with messenger should be of better grade than that just mentioned. It is recommended that for star-connected circuit 2.3 kv. to ground, insulation of 9/64-in. rubber or its equivalent be used. For star-connected circuits 6.9 kv. to ground, the insulation should be at least 8/32-in. rubber or its equivalent. The insulation should be covered and protected with fabric tape, a bronze tape, and circular loom braid. The bronze tape not only protects the insulation, but tends to neutralize static potential and corona. There has

been very little experience in the use of tree wire suspended in cable rings for voltages in excess of 2.3 kv. to ground. It is not the intention of this study to recommend its use.

Cost Data

A study has been made of the relative cost of these different types of construction and Table I furnishes figures of the relative cost of bare copper wire, weatherproof wire, tree wire, and lead covered cable including poles.

Table II covers the cost of replacing short poles with higher poles and transferring the conductor as compared with the cost of replacing the conductors with tree wire or lead covered cable.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

PRIME MOVERS COMMITTEE REPORTS[2]

SINCE steam power is gaining in popularity on the Pacific Coast, interest in its development and operation is growing in intensity. This has been demonstrated by the increasing attendance at the meetings of the prime movers committee held at San Francisco, Sept. 21, 1928, Los Angeles, Jan. 18, 1929, and at Fresno, April 19, 1929.

It is hard to estimate the value of these meetings where men are eager to tell of the things they are proud of and feel just as free to ask for aid on those problems that vex them. The committee has not attempted to do anything radical, but rather to carry forward the work of previous years, making a study of the problems and progress of the various operating companies, and collecting this into the form of reports by the several subcommittees so that all members of the Pacific Coast Electrical Association might have the benefit of the findings. This work has been divided among six subcommittees. The personnel of these subcommittees includes well qualified men, interested in the design and operation of steam plants or their equipment. The following subjects are reported upon:

Boiler and turbine room instruments.
Turbo-generator equipment.
Boiler water and condenser water.
Heat balance.
Boilers, furnaces and accessories.
Condensing equipment.

Boilers, Furnaces and Accessories*

This committee reports upon a novel method of controlling air from forced draft fans by means of shutters instead of with the usual variable speed motors. An original, economical and practical method of keeping standby boilers up to steaming pressure is outlined. A study of refractories of low, medium and high fusion points is presented along with a complete report of a recent development of water walls.

THE SUBCOMMITTEE on boilers, furnaces and accessories has gathered information during the year relating to forced and induced-draft fans, refractories, stand-by boilers and water cooled furnace walls.

Forced and Induced Draft Fans

In the majority of plants the fans are driven by variable-speed motors. In some plants the forced-draft fan is installed beneath the furnace floor and the induced-draft fan above the boiler at the base of the stack. In other plants both the forced and induced-draft fans are located above the boilers. The speed of the fans is controlled by push buttons located on instrument boards of the individual boilers, conveniently located for the use of the operator.

At the Pacific Gas and Electric Company's station "C", Oakland, constant-speed motors are used to drive the fans instead of variable speed and the quantity of air is controlled by vanes which open and close to regulate the amount of gas entering the fan. The opening and closing of the vanes is controlled automatically or by push button from the fire-room floor. In this installation two motors of different speeds are used on each fan. The low-speed motor is operated for the lighter loads and after the vanes become wide open a further increase in load requires the cutting out of the low-speed motor and the starting up of the high-speed motor, at the same time the vanes closing down to their minimum opening. With still further increase in load the vanes gradually open up again. Thus, as the load of the boiler increases from zero to its maximum capacity the vanes of the fan open twice, first with low-speed motor in operation and then with the high-speed motor operating. This method gives a very complete control over the quantity of air entering the furnaces.

Refractories

The following is a statement obtained from the Los Angeles Gas and Electric Company on the subject of refractories:

"It is our experience that the maximum desirable fusion point is Seger Cone No. 31, No. 32, or approximately 3,200 deg. F., the silica content of the brick to be about 63 per cent, and the alumina content to be not in excess of 35 per cent. Brick having a higher fusion point than the above is very prone to spall. Much refractory trouble is due to the method of laying brick generally in vogue, the excessive use of 'fire clay' or 'bonding cement', and the laying up of tight inner walls.

"We use clay in horizontal joints only for the purpose of compensating for slight irregularities between layers of brick, otherwise these joints are made up

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[2] **F. R. Knight,** Los Angeles Gas & Electric Corporation, chairman. **H. S. Markey,** Great Western Power Company of California, vice-chairman. **Edgemoore Iron Company:** G. L. Warden. **General Electric Company.** J. H. Cunningham, H. E. Fuqua, E. E. Valk. **Great Western Power Company of California:** H. S. Markey. **Hawaiian Electric Company, Ltd.:** L. A. Hicks. **Ingersoll-Rand Company:** V. M. Peck. **Los Angeles Bureau of Power & Light:** Roy Martindale. **Los Angeles Gas & Electric Corporation:** G. H. Briggs, M. R. DeLisle, C. H. Zeise, H. E. Thompson, E. G. MacDonald, J. G. Rollow, R. F. Leefeld, Weller Reed. **Leeds & Northrup Company:** L. E. Emerich. **C. C. Moore & Company:** D. P. Vail. **Pacific Gas & Electric Company:** V. F. Estcourt, C. H. Delany, M. E. Mulkey, C. E. Steinbeck. **San Diego Consolidated Gas & Electric Company:** E. D. Sherwin, C. W. Wiggins. **San Joaquin Light & Power Corporation:** A. Y. Meudell, H. T. Shirley. **Southern California Edison Company:** H. C. Bennett, F. G. Philo, W. H. Short, August Sattler, Scott Jensen, L. J. Kraps, Raymond Wilcox. **The Southern Sierras Power Company:** V. E. Johnson. **Westinghouse Electric & Manufacturing Company:** H. S. Warren, R. A. Hopkins.

* Report of boilers, furnaces and accessories subcommittee of prime movers committee, Engineering Section. C. H. Delany, chairman. M. R. DeLisle, V. M. Peck, F. G. Philo, W. H. Short, D. P. Vail, C. H. Zeise.

brick by brick. In the vertical joints clay or cement is used, only on the outer extremity of the joint, toward the furnace the joint is left open and plenty of clearance is allowed between individual bricks.

"In laying walls for the furnaces of our 2,500-hp. boilers erected during 1928, we made an interesting experiment. The brick are of an interlocking and tongue-and-groove type. No clay was used in vertical joints and masons were furnished with a 3/16-in. gage which was inserted into these joints to assure that amount of clearance. The assumption was that if this amount of clearance was found later to be excessive it could be reduced easily by shooting clay into these joints. However, after considerable service examination of the furnace walls showed that fire had not entered these joints, that under operating conditions they had been tightly closed. The above goes to show that the expansion of brick in furnace walls of boilers fired to a high rating is generally underestimated."

The following is a report of tests run on refractories by the Southern California Edison Company:

"The test run referred to in this instance was made on three Pacific Coast makes of fire brick which will be hereafter designated as make Nos. 1, 2 and 3. This test was made using natural gas as fuel. In Fig. 1, numbering from left to right, No. 1 shows a brick of medium fusion point, No. 2 low and No. 3 a high fusion point. The test location is an air cooled bridge wall being one brick or nine inches thick:

A was in service 315 boiler hours
B was in service 370 boiler hours
C was in service 3,292 boiler hours
D was in service 5,256 boiler hours."

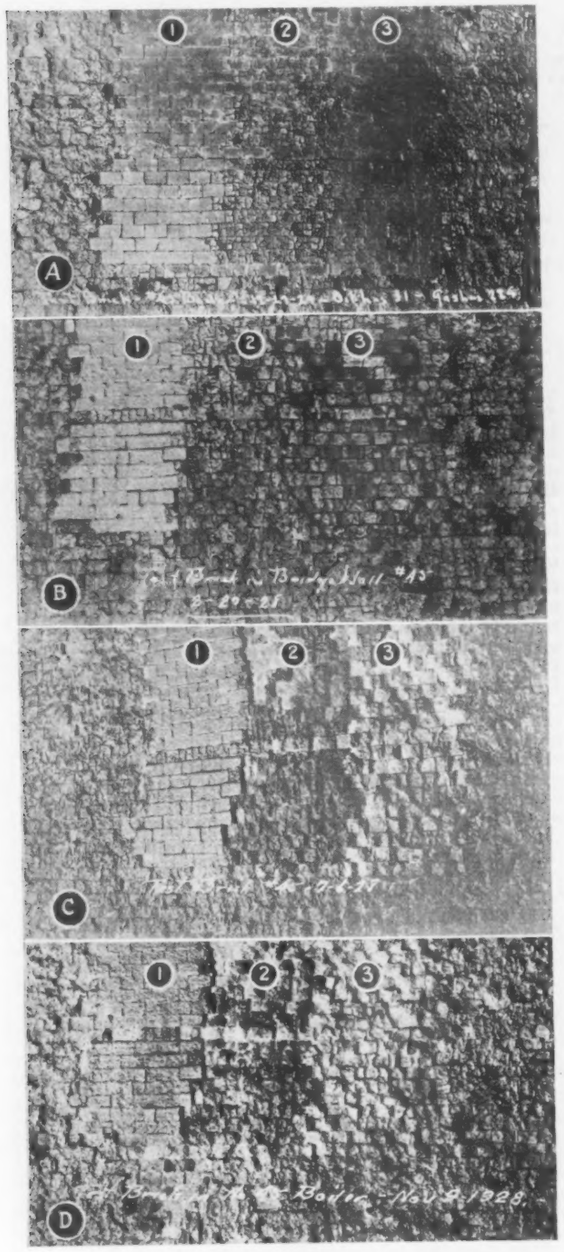


Fig. 1. Experimental brick installations in boiler firebox. (A) In service 315 boiler hours. (B) In service 370 boiler hours. (C) In service 3,292 boiler hours. (D) In service 5,256 boiler hours.

Stand-By Boilers

In the operation of steam plants in parallel with hydro-electric systems it frequently is the custom to operate the steam plants either partially or wholly standing by ready to pick up a load suddenly in case of trouble. With this method of operating it usually is necessary to have a number of boilers hot with full steam pressure ready to generate steam immediately when the fires are lighted. The usual method of keeping boilers hot for this purpose is to fire them alternately; that is, keep the fires burning under one boiler until it is thoroughly heated up, then put them out and light the fires under another boiler.

The Pacific Gas and Electric Company recently has installed a system of keeping boilers hot by bleeding flue gases from a boiler in operation and passing these gases into the furnaces of the boilers to be kept hot. The sketch, Fig. 2, shows the method used. A fan is provided for sucking the flue gases from one of the boilers and these gases are led by a duct along the front of the other boilers, entering the boilers through the front wall above the oil burners. The quantity of gas passing to each boiler is controlled by regulating dampers at the boiler inlets. The fan is operated by a variable-speed motor and the speed is controlled so as to maintain zero pressure in the furnaces of the stand-by boilers.

This method has been applied to six boilers, having a heating surface of 8,226 sq.ft. each. One of these boilers at which the fan is installed is operated continuously, the other five boilers being kept hot by the gases bled from the first one. Tests have shown that the amount of fuel required to keep boilers of this size hot by the old method of alternate firing amounts to approximately three barrels of oil per day for each boiler. If the gases for keeping the boilers hot are taken from the breeching of the first boiler then the other boilers are kept hot entirely by waste gases, so that the whole quantity of three barrels per day for each boiler is saved. In the present installation the gases are driven from the bottom of the second pass and there is some heat remaining in these gases which would be utilized if the boiler were operated without bleeding. This quantity of heat which may be considered the heat required to keep the five boilers hot by the new method is equivalent to 0.6 bbl. of oil per day for each of the five boilers. There is a net saving in fuel oil, therefore, of 2.4 bbl. per day for each of the boilers kept hot by this method.

Other advantages of this method of keeping stand-by boilers hot are:

(a) Stand-by boilers are maintained continuously at full steam pressure instead of an amount below full pressure varying from zero to 25 lbs.

(b) The detrimental effects on furnace brickwork due to sudden and large temperature changes are practically eliminated by introducing a continuous flow of hot gas instead of lighting up fires at stated intervals during the day.

(c) There would be less tendency for corrosion in the cooler parts of the boilers due to their being kept hot continuously instead of being allowed to cool down below the temperature at which the moisture from the stack gases will deposit.

The cost of an installation of fan and ducts such as described is not excessive, the saving in fuel being enough to pay the entire cost in approximately 300 days of operation.

Water and Air Cooled Furnace Walls

As part of this report the subcommittee presents the following from O. H. Hedrich, mechanical engineer of the Municipal Light and Power Department at Pasadena, Calif.:

"When the installation of the boilers for the No. 7 turbo-generator unit of the Pasadena steam plant was being considered in the latter part of 1927 much thought was given to the proper cooling of the furnace walls in an attempt to cut down furnace maintenance and increase thermal efficiency at a reasonable cost.

"All previous boilers at this plant had been of the solid refractory type, either pre-burned shapes or plastic material, and much trouble in the way of boiler outage and maintenance of refractories was experienced. Furnace wall temperatures up to 2920 deg. F. were attained at 250 per cent of rating resulting in melting down even the highest grade of refractories, especially at the bottom of high walls where the compression load was high. It was necessary therefore to provide some form of cooled walls for the new boilers, which had 15,260 sq.ft. of straight tube water-heating surface and a top rating of 326 per cent. To obtain proper combustion it was believed that the heat release should be kept down to something less than 40,000 B.t.u. per cu.ft. per hour. This required a furnace having a volume of approximately 5,500 cu.ft. and due to the width and depth of the boiler this height was necessarily about 15 ft. in front and 20 ft. at the rear wall.

"Certain physical conditions made it necessary to locate the forced and induced-draft equipment on a deck above the boilers and, since the air for combustion had to be piped down to the burners, it was a very simple matter to carry this air in a duct adjacent to the inclined rear wall and under the deck on its way to the burners. In fact the steel plates supporting the refractory in the deck and rear wall were used as one side of this duct and these portions of the furnace are then cooled by the air for combustion.

"The side-wall cooling was more of a problem inasmuch as it was vastly more difficult to provide proper circulation of air behind these walls. Sectionally supported brick or tile walls were abandoned because of their inability to withstand the air pressure required at the high ratings. Cast-iron air-duct walls were satisfactory as far as air conduction was concerned, but were very expensive and did not provide the best protection to

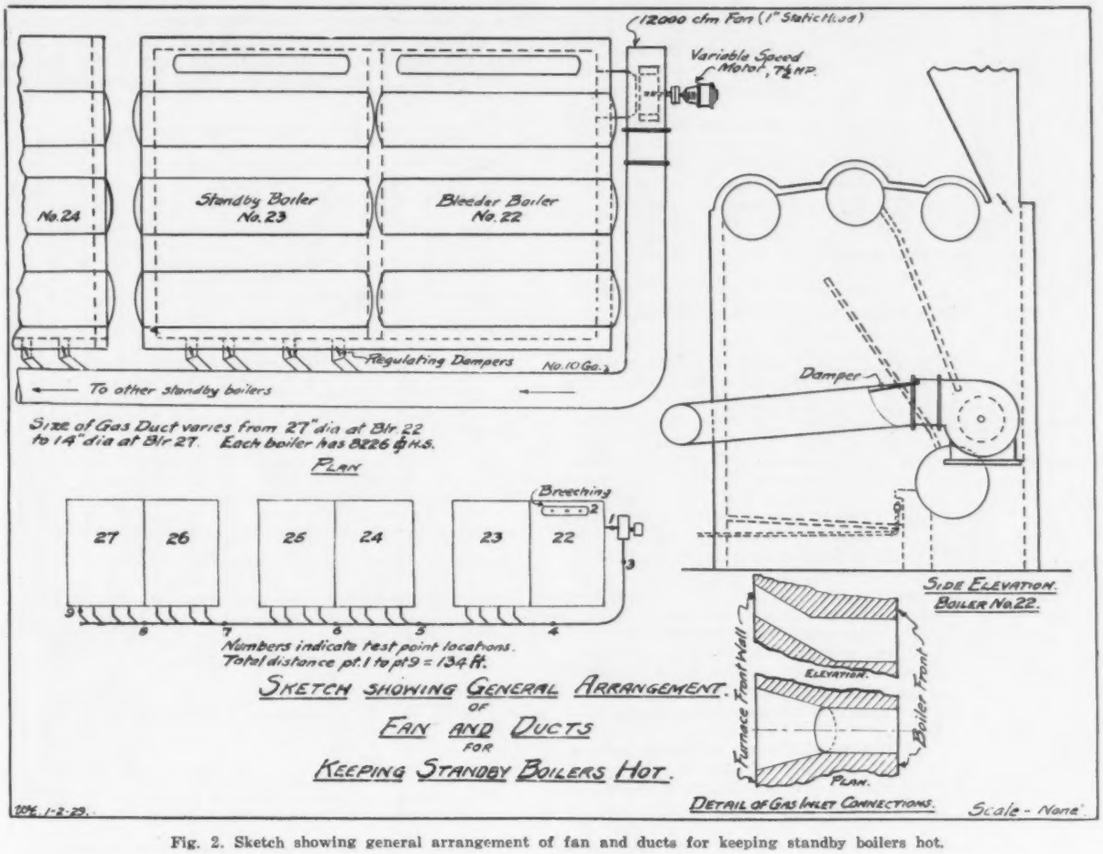

12000 cfm Fan (1" Static Head)
Variable Speed Motor, 7½ HP.
No. 24
Standby Boiler No. 23
Bleeder Boiler No. 22
Regulating Dampers No. 10 Ga.
To other standby boilers
Size of Gas Duct varies from 27" dia at Blr 22 to 14" dia at Blr 27. Each boiler has 8226 ft. H.S.
PLAN
Breeching
27 26 25 24 23 22
Numbers indicate test point locations. Total distance pt. 1 to pt 9 = 134 ft.
SKETCH SHOWING GENERAL ARRANGEMENT OF FAN AND DUCTS FOR KEEPING STANDBY BOILERS HOT.
Damper
SIDE ELEVATION. BOILER No. 22.
Furnace Front Wall
Boiler Front
ELEVATION.
PLAN.
DETAIL OF GAS INLET CONNECTIONS.
Scale - None

Fig. 2. Sketch showing general arrangement of fan and ducts for keeping standby boilers hot.

the refractory lining. The patented refractory-armoured water-tube walls, while eminently successful, were high priced and at that time were having some silght refractory troubles. It was then that the bare-tube wall was considered and eventually adopted.

"As a matter of fact, bare tubes in the side walls do not have nearly as hard service as the first row of

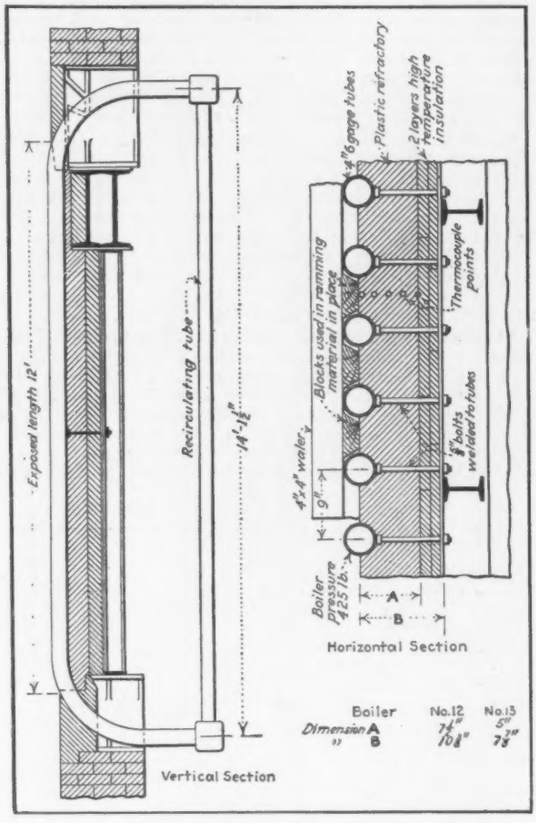


Fig. 3. Section through typical water-cooled wall.

boiler tubes. Side wall tubes must conduct radiant heat only whereas the first row of boiler tubes are subjected to convection as well as radiant heat.

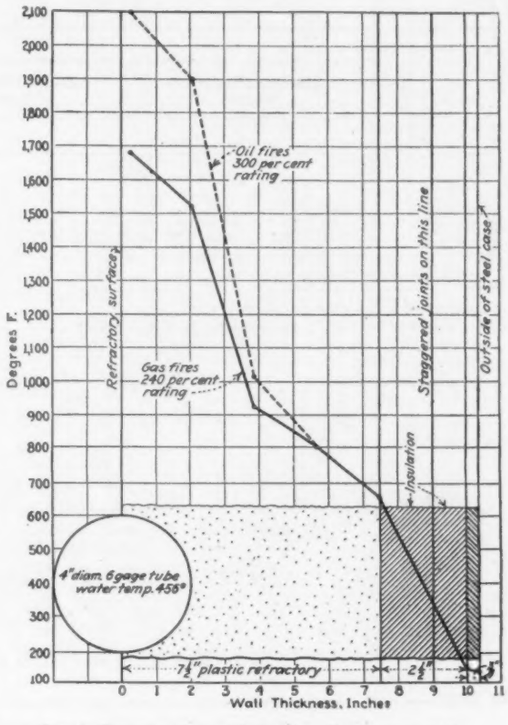
"Originally planned a 'shadow-type' wall was planned, that is, solid refractory in back of or 'shadowed' by a screen of bare tubes two or three inches away. This was given up in favor of a partially imbedded type such as finally was used. Plastic fire brick material lent itself admirably to such a construction, provided of course that it was properly installed. Blocks two inches thick and eighteen inches long were beveled to fit between the tubes and these were backed up by 4x4 walers which in turn were braced to the opposite furnace wall. Two layers of high-temperature insulation with staggered joints were laid against the steel casing plate and the plastic material filled in. Air guns with 3-in. square tamping blocks welded onto the drill were used to drive the plastic in place. It was driven in very firmly so as to become a heavy, dense monolithic wall with no joints.

"At the center of the vertical run of each tube a square-head bolt was electrically welded in place and the threaded end allowed to project through the steel casing. A nut was put on, finger-tight only, and in this way any tendency for the tubes to bulge into the furnace was avoided. The plastic refractory thus was held in place between the tubes and steel casing which in turn were tied together at the top, center and bottom, making it impossible for the refractory to work loose and fall into the furnace.

"In laying out the windbox and burner spacing special care was taken to keep the wing or end burner a minimum of 48 in. from the side walls. Of course any impingement of oil spray on the bare tubes in the wall would result eventually in burning out those tubes. With good atomization and proper air conditions remarkably short flame lengths may be obtained and there is really no danger of tube burn outs if proper precautions are taken in design and operation.

"Thermocouples were imbedded in the refractory as it was being tamped in place in No. 12 furnace west wall at a point slightly above and about four feet distant from the lower left wing burner. This was considered the hottest spot in the furnace. The thermocouple closest to the fire was placed midway between two tubes (that is in the center of the 5-in. refractory surface) and ¼-in. from the surface. The remaining couples were placed at equal intervals throughout the refractory which was 7.5 in. thick. These show a sharp gradient with either gas or oil. It is interesting to note that No. 13 boiler, similar to No. 12 and installed at the same time, had only five inches of refractory in the furnace walls. This dimension was measured from the face or tube center line, the thickness behind the tube being only three inches. Although no thermocouples were placed in this thinner wall it is equally satisfactory and evidently quite as efficient as No. 12 inasmuch as the outside casing temperature is the same.

"When burning oil at 300 per cent rating the flame temperature in the firebox was 2,942 deg. F. at the center and 2,800 deg. at the wing burners. The surface of the refractory near the burners and between two adjacent tubes was 2,445 deg. F. while ¼-in. back from the surface the temperature was 2,100 deg. as shown by No. 1 thermocouple. These temperatures are



Fg. 4. Temperature gradient through furnace walls.

low enough to insure a minimum of refractory maintenance. The walls have been in steady service about six months at the time of this report and show no signs of depreciation so far. Some trouble was experienced at the beginning of operation with the special tile used to finish out the wall at the upper bend of the tube. These tile were hung on cast-iron supports by means of projecting lugs. Due to expansion strains the lugs started to crack off and drop the tile into the furnace. This difficulty was overcome by removing these tiles and ramming in plastic fire brick in their stead. Wedge-shaped fibre strips were placed around the bend of the tube before ramming the plastic, and later were removed to leave a half-inch expansion space around the tube bend.

"It has been impossible to take any pictures of these walls inasmuch as we have not been inside the furnaces since replacing the special tile at the upper end of the tube. The only means of ingress is through one of the burner openings and since inspection from all of the five peep holes indicates that the refractory is in perfect shape, we have not taken the trouble to remove a burner and make an internal inspection."

Boiler Water Control*

This report contains a discussion of boiler water control maintaining the new standard ratio of sulphate to carbonate, by the sulphate phosphate treatment, the reasons and reactions involved where make up is from zerolite softeners, and condensate may be contaminated with sea water. Also a brief statement of hydrogen Ion control as experienced by the Pacific Gas and Electric Company.

WATERS in this district are deficient in sulphate and frequent cases of caustic embrittlement have occurred. In order to supply this deficiency it is necessary to add sulphate to the boiler water. One method of supplying this deficiency is by adding sodium sulphate and sodium phosphate in the boilers. Until recently the figure for the desired ratio of sodium sulphate to sodium carbonate was 3/1. In the new code of the American Society of Mechanical Engineers, it will be stated that the ratio of sodium sulphate to total alkalinity in terms of sodium carbonate should be 0.014 times the steam pressure (sulphates) to 1 alkalinity (sodium carbonate) and at 450 lb. pressure is equivalent to 6/1.

Without treatment there had been frequent trouble with burned tubes and caustic embrittlement. With the sulphate-phosphate treatment there have been no cases of any burned tubes or signs of caustic embrittlement reported to date and the presence of scale is almost negligible. Boilers have run from 2,000 to 3,000 steaming hours whereas under the old method 1,000 steaming hours was considered good.

In order to prevent scale formation water softeners frequently are used ahead of the evaporator. The hypothetical chemical reactions which take place in this treatment of boiler water from the softening of the raw water to the conditioning of the boiler water are as follows:

(1) $Na_2\,2Al(SiO_3)_2 + CaCO_3 = Na_2CO_3 + Ca\,2Al(SiO_3)_2$

Sodium Zeolite + Calcium Carbonate = Sodium Carbonate + Calcium Zeolite

Which for the constituents ordinarily found becomes:

(2) $Na_2\,Al_2(SiO_3)_4 + \begin{matrix}CaCO_3\\CaSO_4\\Ca(HCO_3)_2\end{matrix} = Ca\,Al_2(SiO_3)_4 + \begin{matrix}Na_2CO_3\\Na_2SO_4\\NaHCO_3\end{matrix}$

Sodium zeolite + Calcium $\begin{matrix}\text{carbonate}\\\text{sulphate}\\\text{bicarbonate}\end{matrix}$

$= \text{Calcium zeolite} + \text{Sodium} \begin{matrix}\text{carbonate}\\\text{sulphate}\\\text{bicarbonate}\end{matrix}$

(3) $Na_2\,Al_2(SiO_3)_4 + \begin{matrix}MgCO_3\\MgSO_4\\Mg(HCO_3)_2\end{matrix} = Mg\,Al_2(SiO_3)_4 + \begin{matrix}NaCO_3\\Na_2SO_4\\NaHCO_3\end{matrix}$

Sodium zeolite + Magnesium $\begin{matrix}\text{carbonate}\\\text{sulphate}\\\text{bicarbonate}\end{matrix}$

$= \text{Magnesium zeolite} + \text{Sodium} \begin{matrix}\text{carbonate}\\\text{sulphate}\\\text{bicarbonate}\end{matrix}$

These reactions show a few of the large number of combinations in water containing various salts of calcium or magnesium when filtered through a bed of zeolite or base-exchange mineral.

The reaction when the salt solution is passed through the exhausted zeolite bed to regenerate it, is as follows:

(4) $Ca\ \text{zeolite} + 2NaCl = Na_2\ \text{zeolite} + CaCl_2$

Calcium zeolite + Sodium chloride = Sodium zeolite + Calcium chloride

(5) $Mg\ \text{zeolite} + 2NaCl = Na_2\ \text{zeolite} + MgCl_2$

Magnesium zeolite + Sodium chloride = Sodium zeolite + Magnesium chloride

The soluble chlorides of calcium and magnesium are washed out after the regeneration with the salt solution, and the softening of the raw water starts a new cycle. This softened water contains all the sodium salts in the form of bicarbonates, carbonates, sulphates or chlorides, making the total soluble solids greater after treatment than before. Since all calcium and magnesium salts are replaced by sodium salts, most of the sodium salts are removed in the evaporators.

The main condensers in plants situated near coasts, use sea water for cooling. Condenser leakage is one of the problems hardest to overcome in keeping the ratio of sulphate-carbonate uniform. The ideal condition would be a cooling water having the sulphate-carbonate ratio required for their particular boilers.

When there is condenser leakage from sea water various calcium and magnesium salts get into the boiler water together with large quantities of sodium chloride. To prevent these calcium and magnesium salts forming scale, the sodium phosphate is added and from 3 to 6 gr. per gal. always should be present in the boiler water. The reactions are as follows:

(6) $3CaSO_4 + 2Na_3PO_4 = Ca_3(PO_4)_2 + 2Na_2SO_4$

Calcium sulphate + Sodium phosphate = Calcium phosphate + Sodium sulphate

(7) $3MgCl_2 + 2Na_3PO_4 = Mg_3(PO_4)_2 + 6NaCl$

Magnesium chloride + Sodium phosphate = Magnesium phosphate + Sodium chloride

The phosphates of calcium and magnesium form a sludge and thus prevent scale-forming compounds. Especially with the increase of the sulphate-carbonate ratio and the high sulphate content, sufficient phosphate should be maintained in the boiler water to insure definite conversion of the calcium and magnesium salts to phosphate. Otherwise there is the possibility of what is called "back-sulphating." Where the sodium sulphate added to the boiler water combines, under the influence of heat, with the soluble calcium salts present in the boiler, insoluble calcium sulphate is formed as follows:

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* Report of boiler and condensing water subcommittee of prime movers committee, Engineering Section. August Sattler, chairman. C. H. Delany, V. E. Johnson, A. Y. Meudell, H. E. Thompson, G. L. Warden.

(8) $Ca(HCO_3)_2 + Na_2SO_4 = CaSO_4 + Na_2CO_3 + H_2O + CO_2$

Calcium bicarbonate + Sodium sulphate = Calcium sulphate + Sodium carbonate + water + Carbonic acid gas

Calcium sulphate is the offender in this reaction, as it has the property of depositing as a hard scale on the hottest spots in the boiler and its presence is almost sure to result in burned tubes. By the addition of sufficient phosphates in the presence of alkalinity high enough to bring the phosphates down in the tri-basic form, this formation of calcium sulphate can be eliminated entirely, the reaction being as in equation (6). To insure this reaction taking place as desired the alkalinity of the boiler water should be maintained not less than three grains per gallon expressed as sodium carbonate, otherwise there is the possibility of the formation of less stable forms of calcium phosphate. The phosphates, as stated before, should be maintained at from three to six grains, as Na_3PO_4.

The addition of tri-sodium phosphate also is an excellent preventive for the corrosion occasioned by the presence of magnesium chloride in boiler water, as shown by reaction equation (7). Magnesium chloride is an especially dangerous salt always present in sea water and which, under the presence of the heat in the boiler, forms hydrochloric acid. With corrosion of the boiler steel it again forms magnesium chloride to continue the corrosion indefinitely, the reaction being as in equations (9), (10) and (11).

(9) $MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl$

(10) $Fe + 2HCl = FeCl_2 + H_2$

(11) $FeCl_2 + Mg(OH)_2 = MgCl_2 + Fe(OH)_2$

With the desired conditions in the boiler under this treatment the boiler water should show at least three grains per gallon of alkalinity as sodium carborate, with a ratio of sodium sulphate to alkalinity of 0.014 times the boiler pressure.

To prevent caustic embrittlement it is necessary to keep a proper ratio of the sulphate radical to the carbonate radical, but under the influence of high temperatures and pressures the sodium carbonate is converted into caustic soda so that it is necessary to use other sodium salts to convert the sulphates of calcium and magnesium into soft deposit or sludge. The success of this treatment depends upon the proper portioning of the chemicals used and the efficient blowing down of the boiler or there will be heavy scale formation and an increased tendency of the water to foam due to the excessive amount of suspended solids.

Hydrogen-Ion Control

A statement from the Pacific Gas and Electric Company concerning the hydrogen-ion control in various waters is quoted directly:

"**Raw Water**—When we were using raw water without treatment the only control we had over the hydrogen-ion concentration before the water entered the boilers was the amount of heat we could apply to the water in the open heaters. The raw water as it comes from the wells tests just neutral, pH 7.0. As the well water contains much bicarbonate and sodium bicarbonate included, our water becomes alkaline very quickly after entering the boilers. When we could apply steam enough to the open heaters to keep the temperature up to 212 deg. F., and at the same time leave the water in the heaters long enough to reduce the bicarbonate to the carbonate, the water would have a pH of 8.5 or more or less, depending on the demand for water. It requires about twenty minutes boiling to drive out all of the CO_2 so that we seldom ever had load light enough to get rid of all the CO_2. However, we were never bothered with corrosion as long as we kept the open heaters at 212 deg. We were troubled a great deal with high caustic and hydroxyl alkalinities and the carbonate sludge.

"**Softened Water**—In our water softener we are using lime, soda ash and aluminum sulphate. We aim to control the treatment so that we will have good clear water in the boilers at all times and by making regular tests on the boiler water we can easily control the caustic and hydroxyl alkalinities. We aim to use enough excess lime to get rid of all the CO_2, but not enough to run the hardness of the boiler water more than 4 or 5 deg.

"**Water from Evaporators**—For a short time after we started our new boilers we did not use anything at all to control the pH of the distilled make-up water. In a short time the boiler water began to take on a red cast and soon reached the point where no chemical test could be made, as the color changes could not be seen. We immediately began using tri-sodium phosphate. This keeps our boiler water crystal clear. We have been holding the causticity about fifteen or twenty parts per million so far. This is well on the safe side so far as hydrogen-ion is concerned as it requires a pH of 8.5 before phenolphthalein will produce a color in water. We have not had an opportunity to see the inside of the boilers since we put them on the line, so we can't say for a certainty what the inside appearance is. We may have to use more phosphate, but we want to stay as low as we can and still accomplish proper treatment so as to stay as far away from priming possibilities as possible. So far we are using no other control in these boilers, basing our hopes on the correctness of the investigations of Parr and Hall, both of whom state that phosphate treatment is all that is necessary in an installation of this kind.

"**Water from Deaerators**—We do not have deaerators so will not discuss this point.

"**Water from Condensers**—For our new boilers the same applies to this question as to question No. 3 for evaporated water, since both waters are mixed and fed to the boiler. In the old part of the plant, however, the condensate mixes with the treated make-up water in the open heaters and the make-up water has enough excess caustic to neutralize the pH in the condensate.

"We have no salinometer. However, comparative values of the salinometer with alkalinities of various strengths do not mean anything, unless the make-up water is from a constant source and does not change in the quantity of different ions. Where condensate is mixed with treated or raw make-up, a leak in the condenser, when condensing with salt water, throws all comparisons out. The same applies if the treatment varies at the water softener, and no chemical softener will produce the same treatment day in and day out."

Heat Balance and Station Auxiliaries*

This report includes: (1) Report of proposed installations with a flow diagram study for a 1,200-lb. steam-electric station. (2) Views and description of representative feed-water heater installations on the Pacific Coast, with a flow diagram. (3) Operating and starting characteristics of auxiliary steam driven house-generator sets for emergency use. (4) A description and discussion of evaporator equipment with views of continuous blow-down, and double-distillation system. (5) A report upon the turbine spindle turning device in use at Seal Beach station for quick starting of large turbo generator units.

* Report of heat-balance and station auxiliary subcommittee of prime movers committee, Engineering Section. L. J. Kraps, chairman. L. A. Hicks, H. S. Markey, Weller Reed, C. E. Steinbeck.

(6) Curves showing characteristics of a four-stage extraction system from test results.

DURING the past year modern steam generating equipment of a total capacity of 210,750 kw. has been installed in five steam-electric generating stations in this territory with reports of uniformly successful operation. Plants of this character which are able to produce a net kilowatt-hour on a fuel input of less than 13,000 B.t.u. and with installation costs below $100 per kilowatt are proving keen competitors with hydro development at the present fuel prices.

New Installations

Two additional plants now are under way in the San Francisco territory, a stand-by station for the Great Western Power Company and new units at station "A" of the Pacific Gas and Electric Company. It is proposed to make the latter installation a notable addition to Western steam plants, as it will be the first 1,200-lb. station in this district. The installation will consist of a 1,200-lb. boiler delivering steam to a high-pressure turbine which exhausts through gas and steam reheaters to the low-presure turbine. Details of this plant are not yet complete, but Fig. 1 shows a proposed flow diagram for this station, the completion of which will be watched with much interest by engineers in this vicinity.

Representative Installations

This subcommittee's report for 1927 and 1928 dealt largely with the theory and expected results from various heat-balance combinations. This year's report will extend the discussion with views of and data from actual equipment in some of the more recent Pacific Coast plants.

Once the heat balance of a station has been decided upon the physical arrangement of the equipment requires consideration as to space occupied, ease of operation, and pleasing appearance.

In some cases the use of vertical feedwater heaters proves very satisfactory, an installation of this kind

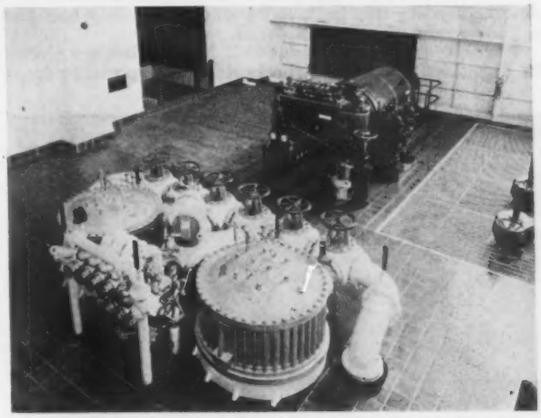

Fig. 2. Low-pressure heaters, Long Beach No. 3 steam plant of the Southern California Edison Company.

being shown in Fig. 2, which is a view of two 4,000-sq.-ft. low-pressure heaters at the Long Beach No. 3 steam plant of the Southern California Edison Company. Steam leads from the extraction openings of the main unit are carried to the heaters in the turbine-room

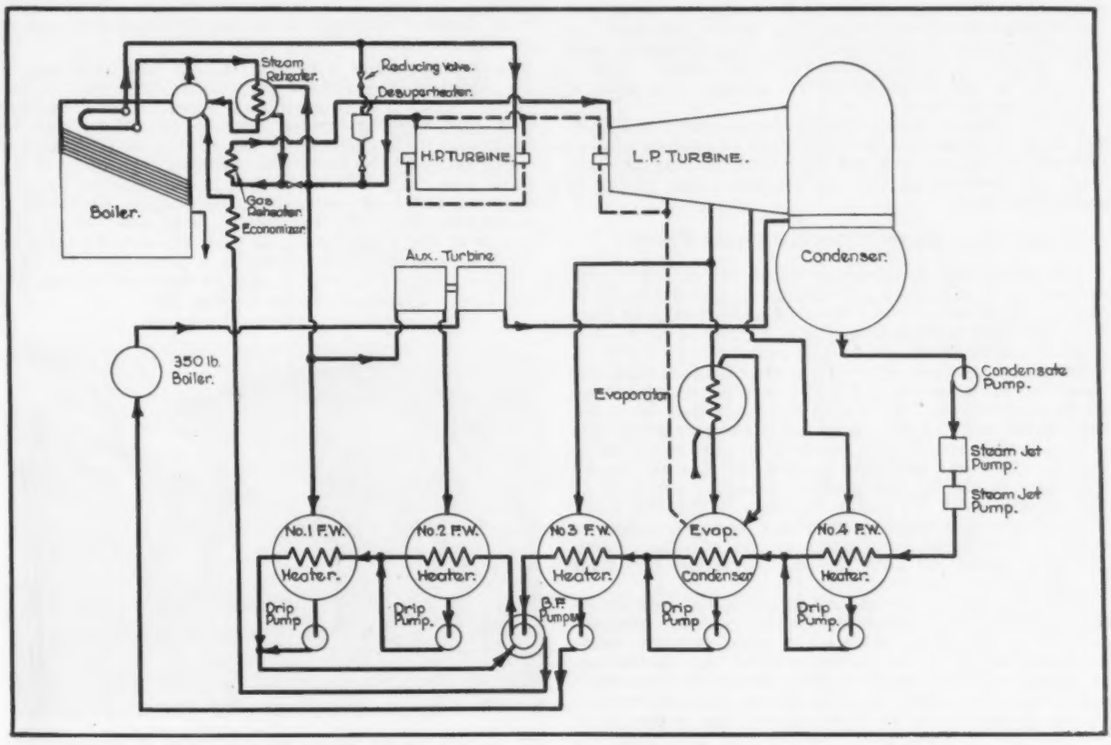

Fig. 1. Proposed flow diagram of 1,200-lb. steam plant of the Pacific Gas and Electric Company.

basement below the level of the main operating floor with control valves operated from the turbine floor. The condensate lines loop through the top of the heaters as shown in the illustration, the three-way valves affording a compact method of bypassing the heaters when required. The heater drip pumps occupy the basement floor space immediately beneath the heaters and the secondary air jets and after-condensers also are included in this unit. The whole assembly occupies a floor space of only 142 sq. ft.

High-pressure heaters for this installation are shown in Fig. 2. They are of the horizontal type built for a

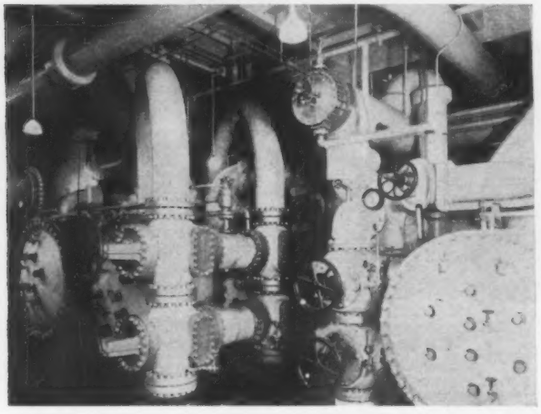

Fig. 3. High-pressure heaters, Long Beach No. 3 steam plant.

water pressure of 650 lb. per sq. in. and 150-lb. steam pressure at a maximum temperature of 650 deg. F. Since the condensate going to these heaters is at full boiler feed pressure the lines were carried through the heater assembly in duplicate, each line being equipped with three-way bypass valves at the heaters. Either line can be taken out of service at any load without interrupting service.

Another typical heater installation is shown in Fig. 4, the high-pressure heaters and drip pumps in station "C" of the Pacific Gas and Electric Company at Oakland. A diagram of the stage heaters and piping is shown in Fig. 5.

Auxiliary Steam Drive for Station Power

The desirability of auxiliary steam-driven house generator sets for the larger steam plants was discussed in last year's report. Since then two of these sets have been installed in this territory. A general view of a 2,500-kw. unit is shown in the background of Fig. 1. This set takes steam from the main steam header, exhausts to atmosphere, and has a water rate of around 26 lb. per kw.-hr. It is a single-stage unit built for very quick starting and is intended for emergency use only. A diagram of the starting system is shown in Fig. 6. The unit normally is shut down with the oil trip valve in the tripped position ready to admit oil to the throttle-valve hydraulic cylinder while the small solenoid-operated throttle valve and the steam bypass valve in the steam supply line to the auxiliary lubricating oil pump are both closed. A voltage regulator is connected to the generator.

When the station frequency drops below safe limits the operator, by pressing the "start" button, energizes and opens the small solenoid-operated throttle valve supplying steam to the turbine driving the lubricating-oil pump. This pump is under control of a pressure regulator. This pump turbine brings the lubricating-oil pump quickly up to speed giving full pressure to the turbine lubricating-oil system and admitting oil through the open oil trip valve into the throttle-valve hydraulic operating cylinder causing the throttle valve to open automatically, admitting steam to the turbine.

The unit very quickly attains full speed and voltage under control of its governor and voltage regulator and is connected by the operator to the station auxiliary bus by means of an interlocked switch which opens the breakers to other sources of auxiliary power just before the emergency set is connected to the line.

Tested starting characteristics of this unit are shown in Fig. 7. The full speed of 3,000 r.p.m. is attained from a cold standstill condition twelve seconds after the "start" button is energized and normal voltage is attained seventeen seconds after the button is operated, four seconds being required for the oil relay system to open the throttle sufficiently to start the unit. The starting time is materially reduced if the unit is warm, as shown by the second set of curves.

Evaporator Equipment

With increased size and decreased number of boiler units it becomes more necessary to guard against failures in the boiler room. Here the operation of the evaporator units plays an important part, as with tight condensers carry-over from the evaporators is the only source of boiler-water contamination and the accumulation of objectionable material in the boilers is extremely slow. The evaporators, however, require frequent blowing down, otherwise they will defeat their purpose by priming to the boiler feed, for they now must remove practically all the waste formerly removed by the boiler blow-down.

By the installation of suitable heat exchangers and orifice-controlled valves practically all the heat usually lost in the evaporator blowdown can be recovered, and the shell concentration automatically held constant at any predetermined value. An installation of this kind is shown in Fig. 8 with a diagram of connections in Fig. 9. The heat exchangers, strainers, orifice control box and blowdown meter are shown in the foreground against the shell of an evaporator built to deliver 16,000 lb. of distilled water per hour, the blow-down equipment serving two such evaporators.

It is proposed in a future addition to this plant, by the addition of a second evaporator condenser to the present system, so to combine the evaporator feed lines that the make-up under normal conditions can be double-distilled, the second evaporator redistilling the water made by the first to be operated separately in the usual way. By this method it is expected to provide make-up water of unusual purity and, by providing a connection from the continuous blow-down from the boilers to the evaporators, to keep the concentration in the boilers so low that it actually is purer than the evaporator feed. The general arrangement of this double distillation system is shown in Fig. 10.

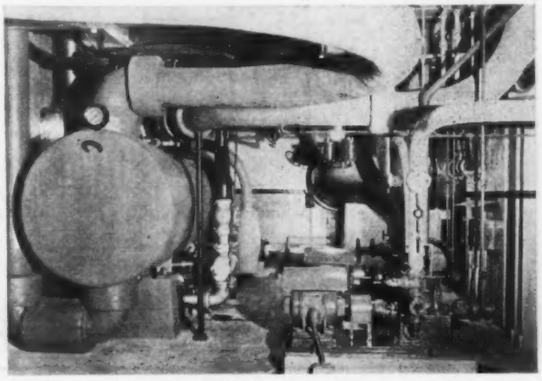

Fig. 4. High-pressure heaters and drip pumps, at station "C" of the Pacific Gas and Electric Company, Oakland.

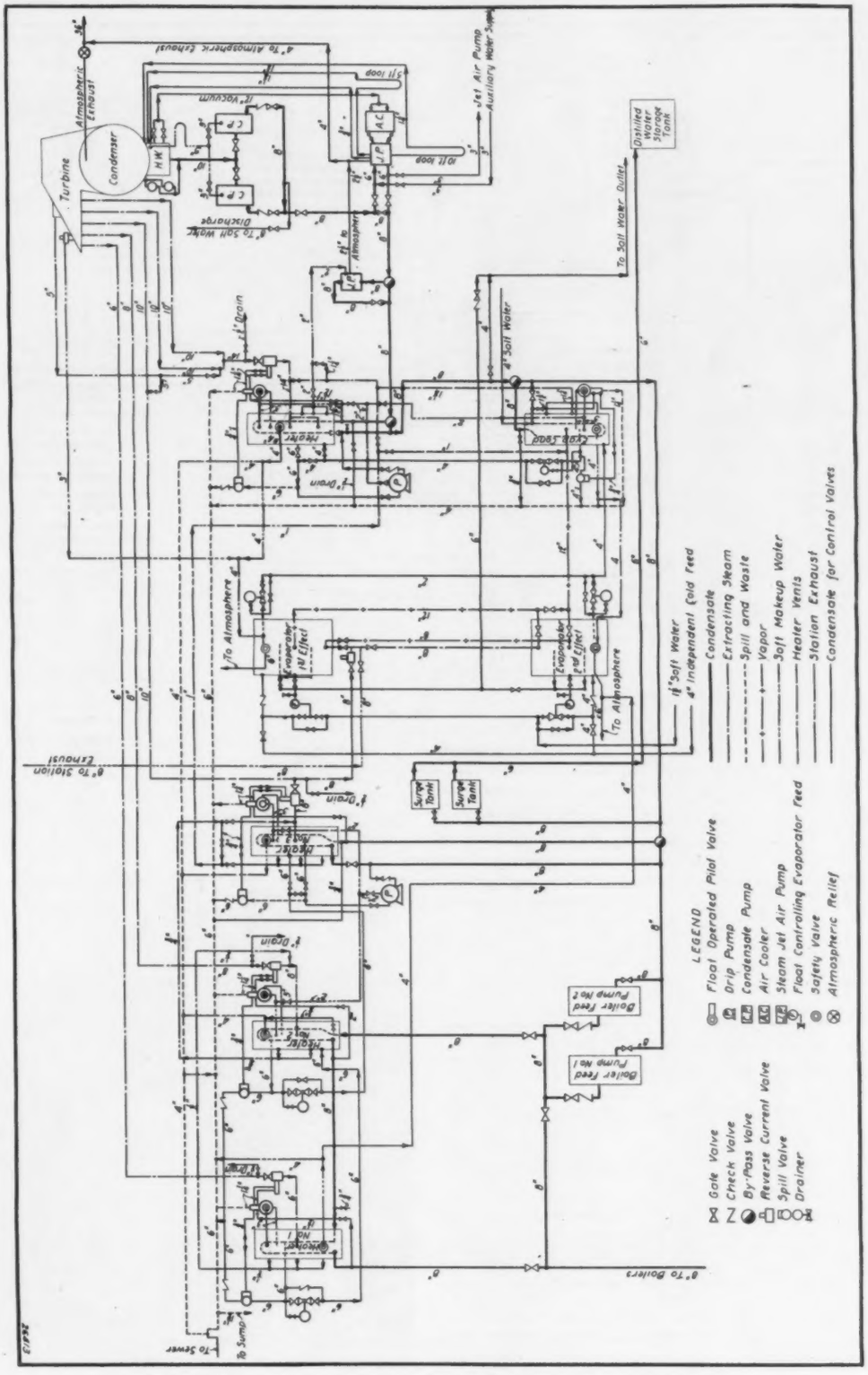

Fig. 5. Flow diagram of extraction system, station "C", Pacific Gas and Electric Company.

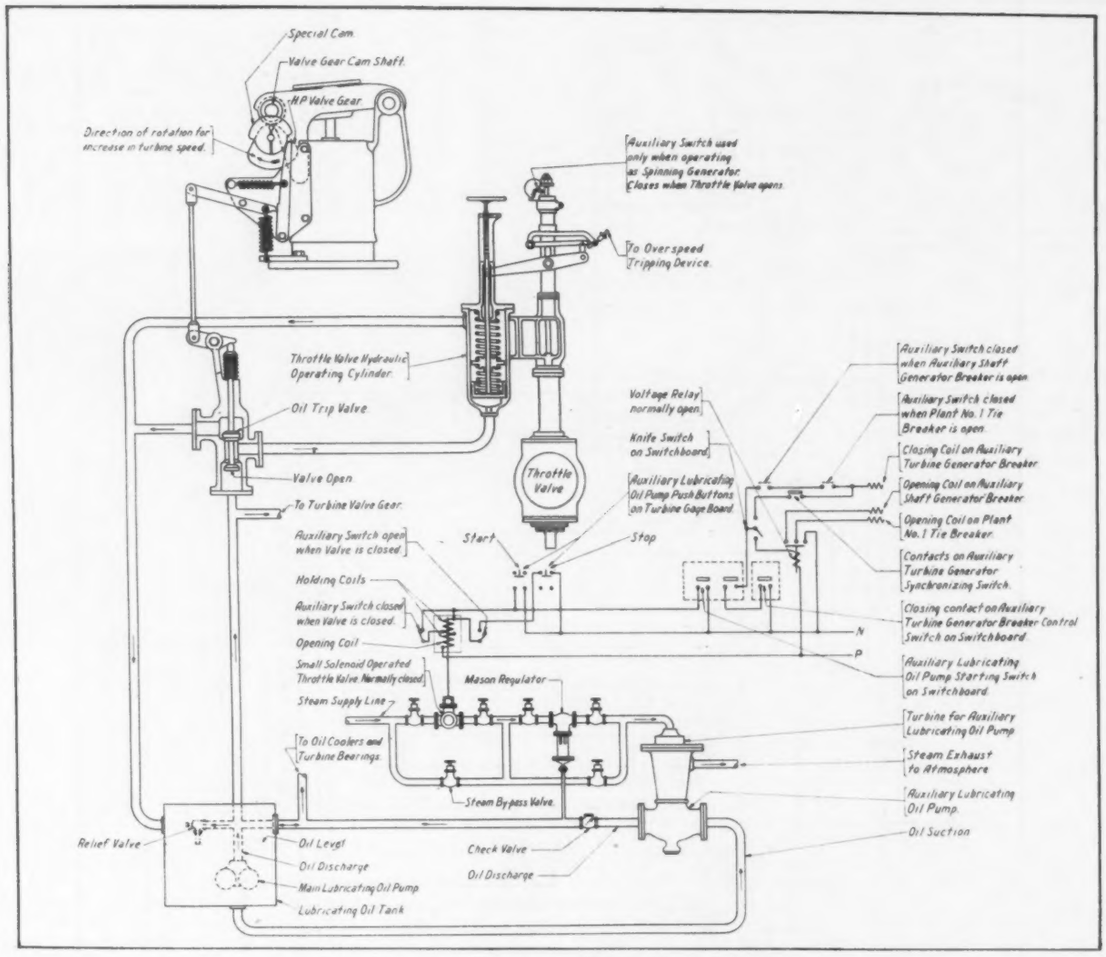
Special Cam.
Valve Gear Cam Shaft.
H.P. Valve Gear.
Direction of rotation for increase in turbine speed.
Auxiliary Switch used only when operating as Spinning Generator. Closes when Throttle Valve opens.
To Overspeed Tripping Device.
Throttle Valve Hydraulic Operating Cylinder.
Oil Trip Valve.
Throttle Valve
Valve Open.
To Turbine Valve Gear.
Auxiliary Switch open when Valve is closed.
Holding Coils
Auxiliary Switch closed when Valve is closed.
Opening Coil
Small Solenoid Operated Throttle Valve Normally closed.
Steam Supply Line
To Oil Coolers and Turbine Bearings.
Steam By-pass Valve.
Relief Valve
Oil Level
Oil Discharge
Main Lubricating Oil Pump
Lubricating Oil Tank
Start
Stop
Mason Regulator
Check Valve
Oil Discharge
Voltage Relay normally open.
Knife Switch on Switchboard.
Auxiliary Lubricating Oil Pump Push Buttons on Turbine Gage Board.
Auxiliary Switch closed when Auxiliary Shaft Generator Breaker is open.
Auxiliary Switch closed when Plant No. 1 Tie Breaker is open.
Closing Coil on Auxiliary Turbine Generator Breaker.
Opening Coil on Auxiliary Shaft Generator Breaker.
Opening Coil on Plant No. 1 Tie Breaker.
Contacts on Auxiliary Turbine Generator Synchronizing Switch.
Closing contact on Auxiliary Turbine Generator Breaker Control Switch on Switchboard.
N
P
Auxiliary Lubricating Oil Pump Starting Switch on Switchboard.
Turbine for Auxiliary Lubricating Oil Pump
Steam Exhaust to Atmosphere
Auxiliary Lubricating Oil Pump.
Oil Suction

Fig. 6. Starting mechanism for auxiliary house turbine.

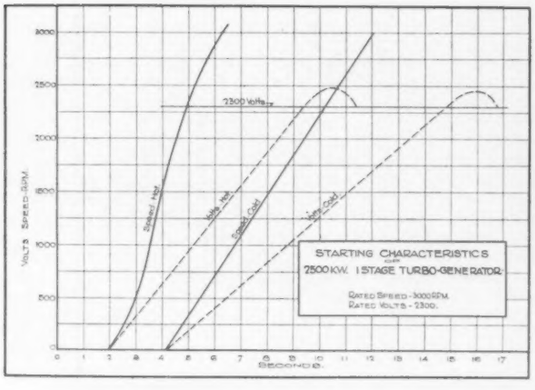

Fig. 7. Starting characteristics, auxiliary house turbine.

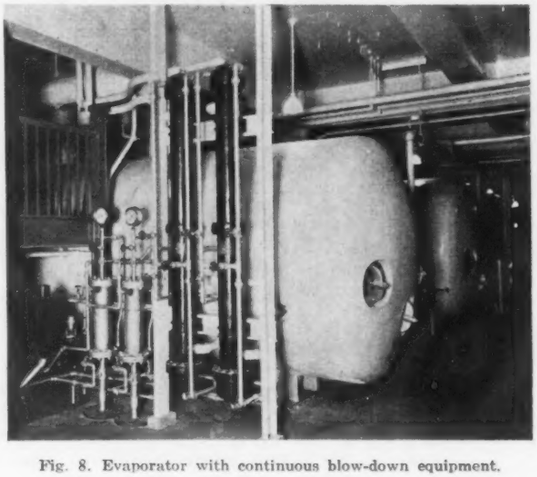

Fig. 8. Evaporator with continuous blow-down equipment.

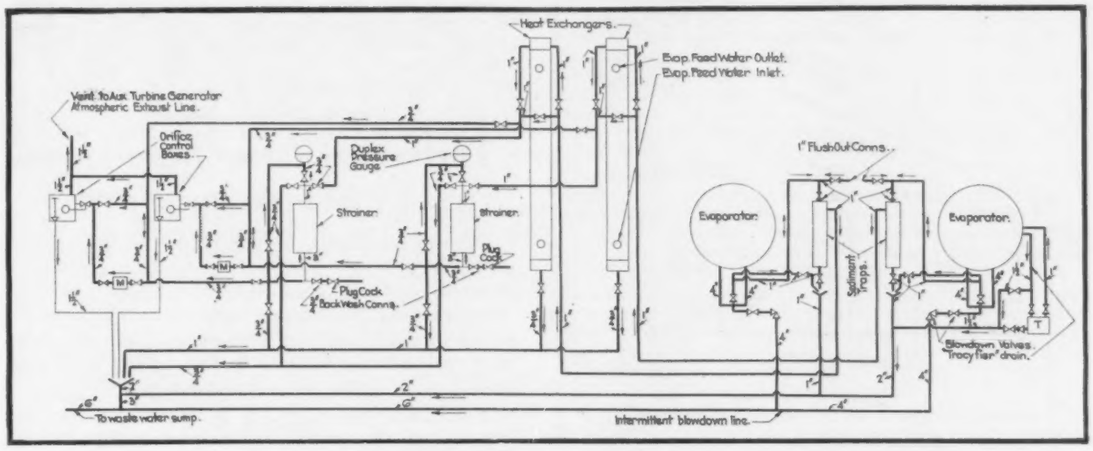

Fig. 9. Diagram of continuous blow-down system for evaporators.

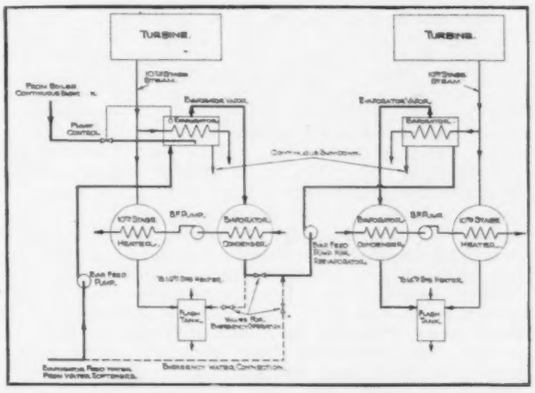

Fig. 10. Proposed double-distillation system for evaporators.

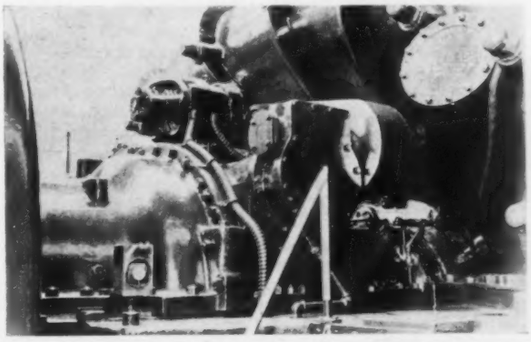

Fig. 11. Turbine spindle turning device on 30,000-kw. turbine, Seal Beach station, Los Angeles Gas and Electric Corporation.

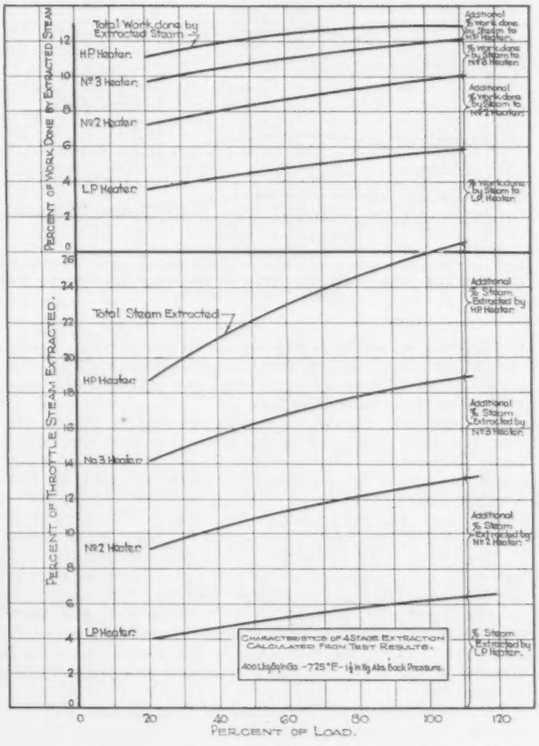

Fig. 12. Fourth stage extraction characteristics. Per cent of steam extracted and work done by extracted steam.

Turbine Spindle Turning Device

One objectionable feature in large present day turbo-generator units is the length of time required to get them in service. It usually requires from one to two hours to warm up the unit and get it up to system speed.

In order to make the unit available at short notice by reducing the warming up period a novel piece of auxiliary equipment has been developed by one of the manufacturing companies and installed on the 30,000-kw. turbine at the Seal Beach station of the Los Angeles Gas & Electric Company. Its purpose is to keep the spindle turning slowly after the unit has been taken out of service and the inlet steam shut off, thereby eliminating the possibility of spindle distortion.

Briefly, this consists of a suitably arranged motor and speed reduction mechanism driving the turbine spindle at a speed of approximately 25 r.p.m. A manually operated clutch is used to engage the worm on the

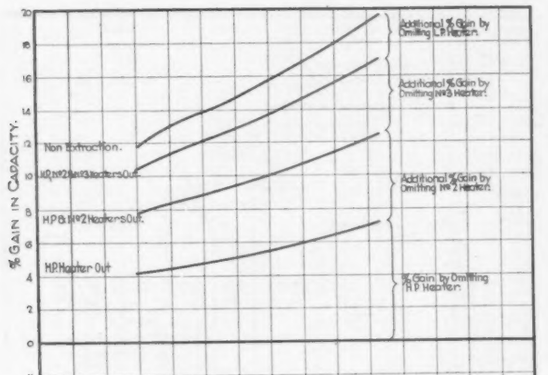
% GAIN IN CAPACITY.
Non Extraction.
H.P.& N°2 Heaters Out.
H.P. Heater Out
Additional % Gain by Omitting L.P. Heaters.
Additional % Gain by Omitting N°3 Heaters.
Additional % Gain by Omitting N° 2 Heaters.
% Gain by Omitting H.P. Heaters.
% LOSS IN ECONOMY.
Non Extraction.
CHARACTERISTICS OF 4 STAGE EXTRACTION CALCULATED FROM TEST RESULTS.
H.P. N°2 & N°3 Heaters Out.
H.P.& N°2 Heaters Out.
H.P. Heater Out.
Additional % Loss by Omitting L.P. Heaters.
Additional % Loss by Omitting N°3 Heaters.
Additional % Loss by Omitting N° 2 Heaters.
% Loss by Omitting H.P. Heaters.
PERCENT OF LOAD.

Fig. 13. Fourth stage extraction characteristics. Per cent loss in economy and gain in capacity by omitting successive heaters, based upon full extraction.

mechanism with the worm wheel on the turbine spindle, the worm wheel being disengaged automatically after steam is turned on the unit and the spindle rotated at a higher speed than 25 r.p.m.

As installed on the Seal Beach unit a 10-hp. slip-ring motor is used and it is ample to rotate the spindle from standstill. High-pressure oil at approximately 1,400 lb. is used on the bearings when starting up from a standstill, but later is cut out and the auxiliary oil pump used for continuous operation. The power required while the unit is rotating at 25 r.p.m. is only 1.1 kw. with high-pressure oil on the bearings and 1.3 kw. with the auxiliary oil pump on. The initial starting torque with the controller "full on" and before the spindle starts to turn is 13 kw. However, the motor will start the turbine with adjusted resistance, on 7.5 kw. The total time required to get the unit from its floating speed onto the line is reduced to approximately 25 minutes.

This equipment as installed at Seal Beach is shown in Fig. 11.

Extraction Characteristics

In operation of stations on the regenerative cycle, some additional capacity may be secured at the sacrifice of economy by eliminating the use of one or more of the extraction heaters. This frequently is made use of during periods of short overloads, and the operator naturally wishes to know the added capacity and loss in economy to be expected under these conditions. Since the high-pressure heaters give the least gains in economy, they should be the first to come out of service.

The curves presented in Figs. 12 and 13 have been prepared from test data on a four-stage extraction system and show the percentage of throttle steam extracted at the various heaters, percentage of the total work done by the extracted steam, and the loss in economy and gain in capacity as successive heaters are disconnected from the system, based on steam flow under full extracting conditions.

Turbo-Generator Operation and Maintenance*

Twenty questions of importance in the operation of modern steam-electric generating stations are covered in this report. Questionnaires outlining these twenty questions were circulated among a group of well qualified persons and the answers in each case are reproduced in full. This information should be of value to operating men.

Question No. 1

HOW MUCH time is allowed for different sizes of turbines for bringing them up to operating speed and is speed gradually increased?

Answers to Question No. 1. R. A. Hopkins—The general practice in the starting of large central station turbines is to roll the spindle for three-quarters of an hour with 10 in. to 20 in. of vacuum at a speed somewhat below 200 r.p.m. At the end of 45 minutes, accelerating the spindle to normal speed is begun, the rate being such as to reach normal speed at the end of one hour. For turbines at the end of the 10,000-kw. line, the starting may be accomplished somewhat more quickly than on the larger sizes mentioned above.

R. F. Leefeld—Until further notice the following schedules will apply under emergency as well as regular operating condition. It should be understood that these schedules are the minimum time that is allowable for rolling, loading, etc. Local conditions may make it necessary to use more time and the judgment of the chief steam engineer or watch engineer on duty will govern the additional time required. Any turbine which has been shut down for six hours will be considered as being cold. Nos. 2 and 3 turbines should take not more than ten minutes each to bring them to full speed, ready for synchronizing. These machines should be loaded at a rate not exceeding 1,000 kw. per minute.

Starting Schedules for Nos. 1, 4, 5 and 6 Turbines

	When Out of Service	Must Roll at 200 to 300 r.p.m.
A	6 hours cold	30 minutes
	5 hours cold	25 minutes
	4 hours	20 minutes
B	3 hours medium cold	15 minutes
	2 hours	10 minutes
	1 hour	5 minutes

It should not take less than six minutes to put Nos. 1, 4, 5 and 6 machines on the governor after the warming period. Synchronizing and loading should proceed at once. If for any reason the load cannot be applied within ten minutes after the machine is on the governor the operator will notify the engineer and he will close the throttle, break the vacuum and allow the machine to roll at approximately 300 r.p.m. with rolling period vacuum.

Under A and B, Nos. 1, 5 and 6 turbines will require the following time to come to fractional and full loads, when cold or medium cold: Under conditions A, Nos. 1, 5 and 6 turbines, put 3,000 kw. on each machine as

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* Report of turbine and generator equipment subcommittee of prime movers committee, Engineering Section. C. W. Wiggins, chairman. E. G. MacDonald, R. A. Hopkins, J. G. Rollow, C. E. Steinbeck, E. E. Valk, Raymond Wilcox.

soon as the machine is on the bus. It is permissible to load the machine at the rate of 1,500 kw. each five minutes until the machine is fully loaded. Under condition B, Nos. 1, 5 and 6 turbines, put 3,000 kw. on each machine as soon as the machine is on the bus, but it is permissible to put 8,750 kw. on each machine as soon as the machine is on the bus; and to pick up 2,500 kw. each five minutes thereafter until the machine is fully loaded.

Under condition A, put 3,000 kw. on the No. 4 machine as soon as the machine is on the bus. It is permissible to load the machine at the rate of 1,000 kw. each five minutes until the machine is fully loaded.

Under condition B, put 3,000 kw. on the machine as soon as the machine is on the bus, but it is permissible to put 5,000 kw. on the machine as soon as the machine is on the bus and to pick up 1,250 kw. each five minutes thereafter until the machine is fully loaded.

F. R. Knight—We have two 35,000-kw. units made by two different manufacturers. The time for starting from dead cold is about one hour on either machine. They are started as soon as vacuum is high enough to prevent the blowing of atmosphere valve from initial rush of steam. Turbine is allowed to run at 300 to 400 r.p.m. for about fifteen minutes, then speed is gradually increased until full speed is attained.

V. E. Johnson—We have two turbines of small capacity, 3,000 kw. and 5,000 kw. The 3,000-kw. machine is standard-speed 1,800 r.p.m., but the 5,000-kw. machine is of 3,600-r.p.m. speed. Either machine is started rolling slowly, but fast enough to seal vacuum then vacuum applied requiring two minutes or so then speed gradually increased up to full speed requiring about ten minutes on the small machine and fifteen to twenty minutes on the larger machine which runs at 3,800 r.p.m. Since it generally is a question of available boiler capacity with us the speed of bringing machines on to the lines has not been stressed. There is a pause in acceleration as soon as speed is high enough to apply vacuum, then probably another pause when machine is running fast enough to apply the field to the generator which gives some additional loading and admits more steam which helps in temperature regulation.

C. E. Steinbeck—On 12,000-kw. units the speed is gradually increased to normal in about twenty minutes. On 37,500-kw. units the speed is gradually increased to normal in about 50 minutes.

L. J. Kraps—35,000- and 50,000-kw. units—normal, one hour, minimum 35 minutes. 94,000-kw. units—normal two hours, minimum one hour. Speed is gradually increased.

E. E. Valk—The general practice in starting up large turbines after a shut-down of four hours or more including starting from a cold throughout condition: unit can be brought to speed in 50 minutes and a load corresponding to approximately 20 per cent of full load applied. After this load has been maintained for ten minutes, full load can be added as fast as steam can be supplied. With small turbines the start can be made quicker.

Question No. 2

If a turbine is cold or if it is warm before starting due to previous operation or due to throttle leakage will there be any difference in time for bringing it up to speed or in method?

Answers to Question No. 2. R. A. Hopkins—Modern turbines are frequently provided with a spindle truth indicator which gives a reading of the deflection of the spindle during starting periods. If such a reading does not exceed, say, 0.002 in. for an average spindle at the end of the normal warming period the turbine can usually be brought up to speed. If the indicator reading exceeds 0.002 in. average deflection it is necessary to roll the spindle at slow speed till a satisfactory condition is obtained. The truth indicator is installed in such a manner that readings are taken in the exposed portions of the spindle near the gland spaces and such readings give the best indications of the conditions of the spindle. In general, if a turbine is warm it may be started more quickly than when cold but this in turn depends on the degree of straightness of the spindle since, through unequal cooling, a warm spindle may sometimes show considerable distortion.

R. F. Leefeld—Starting schedule for cold or warm condition of machine has been answered under No. 1. Leaky throttle is liable to cause distortion of spindle at rest so more time woud be required to soak the kink out. This responsibility is also taken care of under answer to No. 1.

F. R. Knight—If turbine is at a standstill and partly warm, the period of starting is materially increased. Four hours from time of shut-down is the worst, the next four is about the same and at the end of sixteen hours turbine is cold and may be started as in Question No. 1.

V. E. Johnson—Practically no change in method for bringing up a machine which is warm from previous use or throttle leakage.

C. E. Steinbeck—If a 12,000-kw. unit is cold, about one hour is taken gradually to bring it to normal speed. If a 37,500-kw. unit is cold, about two hours are taken gradually to bring it up to normal speed. Answer to Question No. 1 holds if turbines are warm.

L. J. Kraps—On the 35,000- and 50,000-kw. units the time required for starting is less if the unit is warm. On the 94,000-kw. unit it is longer.

E. E. Valk—If turbine has been shut down for a half-hour or so it can be brought up to speed in fifteen minutes, and load applied as fast as steam can be supplied. If the shut-down is near four hours the starting time will be near that given in No. 1.

Question No. 3

After a turbine is on the line how fast may load be added?

Answers to Question No. 3. R. A. Hopkins—It is considered good practice on large turbines to add load at the rate of about 5 per cent per minute, although in cases of emergency load may be added at a much faster rate without injury to the turbine.

R. F. Leefeld—Answered under No. 1 for Alameda Street station. Loading schedule for Seal Beach station calls for 1,000 kw. per minute.

F. R. Knight—After turbine is on line our practice is to load at rate of 1,000 kw. per minute. However, if turbine has required a long time in getting up to speed with the result that exhaust end has become very warm, it is thought advisable to take more time in loading, as spindle and case may cool at different rates which may cause rub on low-pressure gland.

V. E. Johnson—Load is added to these small machines at about 1,000 kw. per minute. There has been no trouble experienced with the turbines on the addition of load but the load is generally applied with regard to boiler conditions.

C. E. Steinbeck—A 12,000-kw. unit will take full load instantaneously. A 37,500-kw. unit takes about 45 minutes to reach full load because of the large size and the extraction heaters.

L. J. Kraps—On the 35,000- and 50,000-kw. units apply 5,000 kw. and hold for fifteen minutes then increase as rapidly as the boilers can supply the steam. On the 94,000-kw. unit, apply 10,000 kw., hold for fifteen minutes, then increase as rapidly as steam is available.

E. E. Valk—See Nos. 1 and 2.

Question No. 4

If it is desired to take out of service a turbine which is carrying full rated load what is considered the mini-

mum time in which the load can safely be reduced to zero?

Answers to Question No. 4. R. A. Hopkins—Modern turbines will permit tripping of the breakers thus removing maximum load in one step if it is desired to do so. Many load dumping tests have been conducted on large turbines of from 40,000- to 60,000-kw. capacity during which maximum loads have been thrown off in one step by opening the breakers, without any damage or evidence of distress.

R. F. Leefeld—In an emergency we do not hesitate to trip the main breakers as this is a condition which is encountered during system disturbances. The main objection to it being the possibility of other equipment failing to pick up the load quickly enough to prevent a partial system outage or a system disturbance. Under ordinary conditions we transfer the load to suit the convenience of the operating and repair crews.

F. R. Knight—Since a turbine is liable to lose load instantly due to line disturbances, we can see no reason why turbine cannot be unloaded as fast as desired.

V. E. Johnson—Load may be dropped off the small turbines in an instant, but this is not practical in normal operation because of necessity for taking care of steam from boiler room.

C. E. Steinbeck—A 12,000-kw. unit may be dropped to zero load immediately. A 37,500-kw. unit takes about one hour for reasons as in Answer No. 3.

L. J. Kraps—Can be instantly, if desired.

E. E. Valk—Entire load can be dropped instantly if necessary. Under ordinary conditions the load is reduced at the convenience of the operator.

Question No. 5

Some large units require an hour and a half for starting and after they are taken off the line special revolving gears or air jets are used to insure uniform cooling of both the stationary and revolving parts to prevent distortion. Are such units flexible enough for the ordinary system?

Answers to Question No. 5. R. A. Hopkins—A spindle and cylinder of any large turbine will become distorted during natural cooling periods because the natural laws of cooling create a circulation of gases which causes the upper portion of the structure to cool less rapidly than the lower portion. If a spindle is started in a partly cooled state vibration may develop or even rubs between stationary and moving parts may take place causing some damage. Because of this fact, turning gears for turbine spindles have been developed which revolve the spindle during cooling stages thus resulting in a uniformity of the cooling. With such a turning gear the hazard of starting is reduced as well as the time required for starting. At the present time there are twelve Westinghouse installations of steam turbines varying in size from 20,000 to 110,000 kw. which have turning gears installed on them. Air jets have been employed from time to time to insure uniform cooling but it has been found that this scheme is not as effective or satisfactory as turning gears. The air jets, however, are found to be of some advantage in preventing distortion of cylinder structures during cooling periods.

R. F. Leefeld—Air circulation on our 30,000-kw. Seal Beach unit has not proved satisfactory and the piping has been dismantled. High pressure oil has been piped under the journals and a jacking gear applied to the coupling together with a motor-driven turning gear. By slowly rotating the spindle distortion can be prevented. We have had no difficulty with our other units. Yes, they are flexible enough for all conditions. We carry enough reserve capacity at all times to take care of a failure of the largest unit operating, so it is a rare condition which makes it inconvenient for us to follow the operating schedules.

F. R. Knight—We have used air cooling on one unit and are not sure it is of great benefit. That has been removed and turning gear applied to same unit. With this equipment we have brought unit up in 45 minutes and believe it can be started even quicker. When spindle is rolling by means of gear, the starting drag on the boiler room is much less.

V. E. Johnson—Regarding the operation of large units requiring one and one-half hours to start, it would appear that such equipment is too delicate for general use. Most any station may expect emergencies wherein they may lose all the load on the turbine quickly, in which case a turbine so sensitive to temperature changes might suffer. It would be too delicate for an ordinary system.

C. E. Steinbeck—Such large units would not be of much use to our system at the present time.

L. J. Kraps—We have no experience with special revolving gears. The present starting time has proved satisfactory with our system where required capacity can be usually forecast. It is practice to have sufficient excess generator capacity on the line to absorb the failure of the largest connected unit.

E. E. Valk—Experience may prove this satisfactory but we have been able to fulfill all starting conditions without the use of special revolving gears or air jets. It must be remembered that quickly heating a heavy steel shell is liable to cause distortion and open the joints; therefore, it is as important that the casing be kept without distortion as the rotating element.

Question No. 6

What comparative differences are required for handling different types of large units?

Answers to Question No. 6. R. A. Hopkins—All types of large turbines are generally required to, and are designed to conform to a common standard of operation. For example, starting from cold and taking on full load in one hour is the commonly recognized practice for central station turbines in this country. If is recognized also that designs should permit of bringing the rotors to speed very quickly in case of emergency without danger, although greater hazards accompany these shorter starting periods.

R. F. Leefeld—There is no material difference in the starting, loading and operating of our units of different make, but of similar capacity and arrangement.

R. F. Knight—Cannot see that there is any great difference in ours.

V. E. Johnson—Our experience is limited to the smaller capacities.

C. E. Steinbeck—We have only one large unit.

L. J. Kraps—Our modern units are practically all the same type, with some variation in heater arrangement. All are handled practically the same.

E. E. Valk—In general all types of large turbines require similar handling. When special handling is required it is usually determined by local conditions.

Question No. 7

If a turbine usually operates without vibration and if it should at some time vibrate when putting it into service, what might be the cause of the vibration and what might be done to eliminate it?

Answers to Question No. 7. R. A. Hopkins—The most common cause of vibration in starting the turbine is the temporary distortion of the rotor caused by unequal cooling during a shut-down period. By means of the truth indicator which has been mentioned, such temporary distortions can easily be detected. Another probable cause of vibration may be distortion of the cylinder from a leaky throttle. It is possible for large cylinder structures to become so distorted that the gland, blade or diaphragm rub may take place. In the event of trouble of this kind developing steam should be shut off the header and the cylinder be permitted to cool sufficiently to reduce this distortion. It is be-

coming rather common practice to provide a large vent between the throttle and governing valves which is opened during shut-down periods. It has also been suggested that two throttle valves with an atmospheric vent between them be provided. This arrangement would be the most effective, though somewhat costly. Vibration has also occurred in some cases during starting periods due to the failure of the supporting feet to slide. This may be caused by lack of proper lubrication or to a distortion of the foundation.

R. F. Leefeld—Vibration can come only from the rotating members, and our experience seems to indicate that when severe vibration occurs during the starting period it is necessary to reduce the speed and let the warp soak out. The practice is to listen in on machines during both the starting and stopping periods. A rub is a rare occurrence. If one should persist it would be necessary to open the machine. Broken blades do not always make themselves known by noise or vibration as machines have lost nearly all of their blades without the operators being aware of it.

R. F. Knight—The usual reason for a turbine vibrating on start is a distorted spindle, due to non-uniform cooling. This can be corrected by slow rolling until all parts are uniformly heated which will be indicated by spindle running smooth when speed is increased, which may also be checked by vibrometers on pedestals.

V. E. Johnson—Vibration may be due to unequal heating of the spindle, if steam were allowed to leak into the turbine while standing. Vibration might also be due to deposit within the shroud rings. We find that on starting a turbine it will vibrate if the exhaust temperature is allowed to remain high as at starting, in which case it is necessary to stop acceleration or lower speed until exhaust temperature is reduced.

C. E. Steinbeck—Vibration while starting is due to unequal absorption of heat by the metal in the turbine. This vibration may be eliminated by closing the throttle for a few minutes to allow the metal in the turbine to become evenly heated.

L. J. Kraps—The most frequent is uneven heating and is sometimes remedied by reducing the vacuum for a short time to raise the shell temperature. Loose coupling bolts also sometimes cause vibration which can be reduced by a thorough tightening.

E. E. Valk—If turbine is handled as prescribed this should not occur and if it does it should be brought to the attention of the manufacturer's representative.

Question No. 8

How often are turbines operated above rated speed to test emergency governors?

Answers to Question No. 8. R. A. Hopkins—In the case of emergency governors not equipped with oil-pressure tripping devices or test weights the overspeed stops should be checked by overspeeding once every month. Proper tachometers should be provided to check the speed during such overspeed tests.

R. F. Leefeld—Once a year at Seal Beach station on No. 1 unit except in case there is reason to doubt the correctness of the adjustment of the stop weight spring. Every 30 days on No. 2 units. Once a week on Nos. 1, 4, 5 and 6 at Alameda Street station.

R. F. Knight—The trips are all checked twice per month to see if the throttle and valves close properly. The throttle trip is tried each time turbine is put on line. Overspeed runs are made once per month for checking emergency governor.

V. E. Johnson—Turbines are operated overspeed to test overspeed trips not more than once a year.

C. E. Steinbeck—About once a week.

L. J. Kraps—Routine test once a week.

E. E. Valk—Once a month in regular service and before the turbine is put back into service after having been idle for repairs or adjustment; if equipped with oil emergency governor once every three months. (See Par. 9.)

Question No. 9

If test weights are used or oil is let into the emergency governor how often are tests made?

Answers to Question No. 9. R. A. Hopkins—On Westinghouse turbines the overspeed stop weight can be forced out at any time by pressing the oil supply plunger until it strikes the end of the spindle and then admitting oil from the governor line through this connection into the passages in the stop body, thus forcing the stop weight outward to operate the trip gear. This oil-tripping device should be operated once every week if the turbine is shut down frequently. If the turbine is on the line for longer periods, it should be operated at each shutdown. On turbines provided with this oil tripping device, actual overspeed tests should be made at three-month intervals.

R. F. Leefeld—At Seal Beach station we attempt to do this once a month but operating conditions do not permit us following this rule exactly. At Alameda Street station Nos. 1, 5 and 6 units are tripped off the line at least once each week with oil in the governors.

F. R. Knight—The trip is made from switchboard and by admitting oil at turbine.

V. E. Johnson—Overspeed tests are always made by forcing governor and making turbine run overspeed, as no provision is made for test weights or letting oil into emergency governor.

C. E. Steinbeck—Test weights are not used. The oil trip is tested about once a week.

L. J. Kraps—Not used. Blocking device is tested for pull apart with weights once a week.

E. E. Valk—On all oil trip emergency governors there is a definite relationship between the tripping speeds with and without oil. This is determined and used as a monthly test so that it is unnecessary to make all speed tests oftener than mentioned in Par. 8. We also recommend operating oil trip before going on the system and shutting down.

Question No. 10

If it is desired to carry a block load on a turbine how is the governor controlled?

Answers to Question No. 10. R. A. Hopkins—There are two schemes in use; the first, covering the case where the turbine is required to take a certain limiting load, but is not required to exceed this load in case of trouble on the system. In this case, a step is arranged in the governing mechanism so that the opening of the valves can be definitely limited to the amount corresponding to the load it is required to carry. The valves are in a position to close should load be lost but cannot be opened because of the adjustable stop which must be altered by hand if a higher load is desired. With this arrangement, after the stop is set, the speed changer is usually tightened to be sure that slight changes in frequency will not move the valves.

With the second arrangement, a load-limiting device can be provided in which there is a slip joint in the governing mechanism that will pull out with some definite reduction in speed, say 1 or 2 per cent. With this arrangement the adjustable stop can be set to limit the load to any definite value within the working range so that small variations in frequency will not change the load on the turbine. The slip joint is so designed that should a sudden demand come on the system the regulating force of the governor is sufficient to operate the slip joint and move the valves to carry the desired load. In the same manner a sudden reduction in load causes the joint to slip and close the valves as required.

R. F. Leefeld—We do not ordinarily operate this way but on several occasions we have set the throttle to

the desired load. During the 1924 power shortage we ran one of our 60-cycle 17,500-kw. units on 50 cycles for the Southern California Edison Company. This was done by limiting the throttle opening in order to limit the load, no change being made in the governor. Friction devices, auxiliary springs, etc., have been used and are partially successful.

F. R. Knight—From switchboard only.

V. E. Johnson—Block load is carried only by making the regulation of the governor sluggish or by setting throttle to limit load and setting governor to carry more load than block desired.

C. E. Steinbeck—The only block load our turbines carry is zero loads. To hold the turbine close to zero we have a bypass around the control valves which is opened just enough to hold zero load. Then the synchronizing spring is set in its lowest position so that slight changes in the system speed will not open the main control valves.

L. J. Kraps—A blocking device is attached to the governor arm limiting the upward travel to any amount as set by a turn-buckle, a spring loaded ball and socket joint in the devices is set to pull apart at a reduction of system speed of 5/10 cycle, leaving the governor free for normal operation.

E. E. Valk—This can be done by an adjustable stop, either motor or hand operated, which will definitely limit the travel of the governor gear if it is desired to operate at a fixed maximum load. Provision is made to permit control valve to close if load is lost.

Question No. 11

Are any special control devices used when operating with hydro-electric system or with another steam power plant? If so, describe them.

Answers to Question No. 11. R. A. Hopkins—No special controlling devices are required when a number of steam power plants are operated in parallel. When steam turbine units are operated in parallel with hydro-electric plants, it is possible when certain types of waterwheel governors are used to get a high momentary speed variation which may reach 30 per cent above normal. If a combined system, which includes waterwheel generators and steam turbine generators, is suddenly unloaded in such a way that the waterwheel generators and steam turbine units remain in parallel, then the waterwheel generators can operate to overspeed the steam turbine, unless the proper precautions are taken. It is understood that on systems where the waterwheel governors must be arranged to permit speed variations exceeding 10 per cent the hydro-electric units are automatically tripped off the system at approximately 10 per cent over-speed. This arrangement should protect the steam turbine units against excessive over-speed. Large steam turbine rotors are ordinarily given over-speed tests from 20 to 25 per cent at the factory. A 10 per cent over-speed should not be exceeded in the field.

It is considered that an interconnection between the over-speed stop and the machine breakers on steam turbine units that are employed in conjunction with hydro-electric equipment would be an additional safeguard against a possible over-speeding of the steam turbines in the event that the waterwheel generator relays refuse to work. In connection with high-head impulse wheels in which deflecting jets may be used, no special governing equipment should be required, provided the maximum over-speed of the waterwheel generators does not exceed 10 per cent when the maximum load is removed in one step.

R. F. Leefeld—We do not operate in parallel with hydro-electric systems. We do not find it necessary to make changes in the governors in order to operate our stations in parallel.

F. R. Knight—We are using no special control devices.

V. E. Johnson—No special control devices are provided to use when operating with hydro plants or other steam plants.

C. E. Steinbeck—Our 37,500-kw. unit is equipped with a load limit device. The device may be set at any load desired and as the predetermined load is reached this device counteracts the governor and prevents the control valves from opening further. We use this device to prevent the turbine from overload or too great a sudden increase in load in case of hydro power failure.

L. J. Kraps—None used. One machine or one plant usually carries the regulation for the system with the others blocked.

E. E. Valk—When operating only with another steam plant no special control devices are required. When operating with hydro-electric system a steam bypass around the first control valve is installed for supplying steam if motored. The throttle valve is provided with a switch which is connected to the generator breakers and will cut the generator off the line if the throttle is closed.

Question No. 12

How often and to what extent are turbines dismantled for examination?

Answers to Question No. 12. R. A. Hopkins—It is the present recommendation that large turbine equipment be examined approximately six months after installation, as it is during this period of operation that troubles due to defective workmanship or materials will develop, if any exist. After the first examination, it is then believed that if the hazards of opening the turbines be balanced against the probability of trouble, the opening period should be extended to from one- to two-year intervals, preferably nearer the two-year periods. This should be modified, however, in the event of major repairs such as a fairly complete reblading, or after extensive changes required because of new operating conditions. In such cases it is believed worth while to open the machine say in from six to eight months after the major repairs have been completed and then extend this to the normal period of operation without overhauling.

Modern turbines are supplied with many access holes through which a fairly good idea of the condition of the interior can be obtained. For example, our Milwaukee turbine has four access holes, covered by blank flanges, through which the condition of the first strip of the dummy can be seen and examined. These holes are on 45-deg. lines, so that two points in the cover and two in the base can be examined. There are likewise four access holes around the circumference of the impulse chamber through which a partial examination can be made of the last row of impulse blades. The last row of low pressure spindle blades is accessible through generous manholes provided in the exhaust chamber. Turbine designs have also advanced to the point where the reliability factor is of a much higher order than it was a few years ago. Improved blade fastenings, stronger blade materials, and improved methods of lashing have all operated to increase the confidence of both builders and operators to the point where the extension of the standard overhaul period seems desirable.

R. F. Leefeld—As nearly as possible we make a yearly inspection at which time we make necessary repairs, clean, paint, etc., spindles are removed, bearings opened, etc.

F. R. Knight—Turbines are completely dismantled once per year, when they have been in nearly continuous service.

V. E. Johnson—Turbines are opened for inspection after a year's operation or otherwise if indications point to necessity for inspection and overhauling.

C. E. Steinbeck—Turbines are examined through the handholes and manholes. They are only dismantled for repairs found necessary by inspection or known to be necessary from previous dismantling.

L. J. Kraps—Once a year for inspection of turbine blading, valves and bearings.

E. E. Valk—It is recommended that the turbine be completely dismantled at least once a year for general inspection of all parts.

Question No. 13

How often are the windings of the generators cleaned and how are they cleaned?

Answers to Question No. 13. R. A. Hopkins—So far as possible, the stator windings of turbine generators should be cleaned once a year. Cleaning should consist of blowing off any loose dust and if there is any indication of oily deposits on the end windings a rag moistened in gasoline or carbon tetrachloride should be used to wipe off the surfaces. If there is danger of explosion if gasoline vapors are allowed to escape into the room, then a mixture of equal parts of gasoline and carbon tetrachloride or carbon tetrachloride alone may be used. Carbon tetrachloride is non-inflammable but care must be taken if the work is being done in a pit. The carbon tetrachloride fumes are heavier than air and might cause suffocation unless the ventilation is good. Gasoline is the least injurious to varnishes and should be used where possible.

R. F. Leefeld—They are cleaned, painted, etc., at the time of yearly inspections if necessary. They are blown out with air under pressure and by use of wiping devices, etc. Washing with gasoline is resorted to, to remove oil, etc.

F. R. Knight—The end coils are blown out and inspected about once per year and given a coat of finish varnish, the balance of the winding once in two or three years, unless we should have reason to believe that they need cleaning sooner due to a rise in temperature or some such reason.

V. E. Johnson—Generator windings are cleaned once a year by brushing by hand or scraping and brushing and applying a coat of insulating varnish.

C. E. Steinbeck—Blown with compressed air about once a year.

L. J. Kraps—Cleaning of generator windings has not been found necessary with the closed air system in use with these units.

E. E. Valk—The frequency with which it is necessary to clean generator windings is largely a matter of local conditions and the type of ventilating system used. If the machine is taking air from outdoors, with no provision for cleaning the air, the cleaning period should be at least every six months.

If we take the impurities in the air as being only some 3 or 4 per cent, which would represent fairly pure air for that surrounding the ordinary power plant, then a 30,000-kw. generator would pass through its ventilating system every 24 hours an amount of foreign matter roughly equal to the weight of the machine. Obviously only a small portion of this foreign matter remains in the machine. Even where air washers are used the air still contains some impurities and experience has shown that where any considerable amount of soot is present in the air, this soot is carried through the washers and owing to its moist condition, adheres more readily to the windings than if dry. Also, such an accumulation is often more difficult to remove than where it is dry.

The cleaning most often recommended is to wipe off the accumulated dirt with gasoline or carbon tetrachloride. The ventilating passages of the rotor are designed so that they can be swabbed out with a stiff brush which will remove any accumulated dirt. Experience with closed circuit systems of ventilation has not been of sufficient length of time to draw definite conclusions regarding the necessary cleaning periods. Machines that have been inspected after two years of service, however, were found to be free from any accumlated dirt and in such condition that the varnished surfaces were still bright.

Question No. 14

How often are revolving fields removed for examination and cleaning of the field and armature windings?

Answers to Question No. 14. R. A. Hopkins—In general, operating people do not remove the rotors, being satisfied with what inspection can be made with the rotor in place. If the rotor insulation resistance is over a megohm, nothing need be done to the rotor except to wipe off around the collector. If the insulation resistance is below this, then the end windings should be blown out as thoroughly as possible, being careful not to injure the insulation by blowing high pressure air against mica surfaces. This cleaning may take considerable time since the dirt is difficult to get at. The cleaning should be continued until there is some indication of the insulation resistance coming up. If no further improvement can be obtained and if the insulation resistance is over one megohm, it would be well to spray the end windings with a baking varnish. If the insulation resistance cannot be raised to one meghom or better, the manufacturer should be called in.

If there is sufficient time to remove the rotor, we feel this good insurance. A better inspection of the stator can be made and there is a better chance to detect loose stator wedges or damaged spots in the iron. There is also an opportunity to inspect the rotor surface for unusual hot spots which might be caused by single-phase operation or bad short circuits, and serves as check on operating methods.

R. F. Leefeld—See No. 13. At Seal Beach station I do not consider it necessary to remove the field as the generator air cooler is practically dust proof.

F. R. Knight—We have only removed the field once in three years. I do not know that there was any necessity for it then. It was convenient to do it, so we did it.

V. E. Johnson—Revolving fields are not removed for cleaning or examination.

C. E. Steinbeck—The fields are examined in place and blown with air about once a year.

L. J. Kraps—As in No. 13, field windings do not accumulate dirt, and it has not been found necessary to remove them.

E. E. Valk—See No. 13.

Question No. 15

What is the maximum temperature allowed in generator windings?

Answers to Question No. 15. R. A. Hopkins—All large turbine generators are insulated with mica on both the stator and rotor. The methods of application are different in the two parts, and for this reason, different temperature limits exist. The rotors are insulated with molded mica cells with mica strips between turns. The coils are wound into the slot, a turn at a time. The mica itself will stand 150 deg. C. with safety, but the A.I.E.E. rules allow a margin of safety and recommend a temperature of 90 deg. plus 40 deg. C. for the temperature of the cooling air, giving a total temperature of 130 deg. C. The stator coils must be insulated for high voltage and the only feasible method is to insulate the coils before installing them in the stator. The insulation adheres to the coils and because of the expansion and contraction of the coils with changes in temperature, the insulation moves relatively to the slot sides. Although the insulation itself is safe at 150 deg. C. yet because of the possibility of mechanical movement and because the coils must be wound into the machine after insulating, the A.I.E.E. have recommended a temperature rise of 80 deg. or a total temperature of 125 deg. C. As a matter of fact, the manufacturers have found their biggest problem is to meet the 150 deg. C. on the field and that when they do this they can guarantee a total temperature on the stator of 100 deg. C. with 40 deg. C. cooling air.

R. F. Leefeld—The maximum temperature for generator windings is 80 deg. C.

F. R. Knight—We have never reached a maximum temperature, but feel 85 deg. C. the limit.

V. E. Johnson—Maximum temperature allowed on generator windings is 80 deg. C.

C. E. Steinbeck—Ninety degrees centigrade.

L. J. Kraps—Maximum temperature 80 deg C. on 35,000- and 50,000-kw. units. 95 deg. C. on 94,000-kw. unit.

E. E. Valk—On our turbine-generators the guaranteed rise is 60 deg. C. on the armature and 85 deg. C. on the rotor. Our practice, especially on the larger sizes, is to make these machines with as low temperatures as is consistent with other factors of design. Such machines, we believe, owing to decreased expansion difficulties, give much longer life and will be freer from other troubles than those designed for the limits fixed by the American Institute of Electrical Engineers, for the class of insulation used. Class B insulation is used throughout on both stators and rotors.

Question No. 16

Are alarms used to operate at dangerous temperatures?

Answers to Question No. 16. R. A. Hopkins—So far as we know, alarms are not used. The temperatures of the machines are measured by detectors embedded in the machine and the temperatures are read by meters on the switchboard. If unusual load conditions exist, then the temperatures may be watched more closely.

R. F. Leefeld—No.

F. R. Knight—No alarms used. Operators take readings every half hour.

V. E. Johnson—No alarms are provided on our generators at this plant.

C. E. Steinbeck—Yes.

L. J. Kraps—Alarm contacts and annunciator system is used.

E. E. Valk—Not generally. A few of the installations have been equipped with alarms in the air circuit for the purpose of giving warning in case the air temperatures reach a predetermined value.

Question No. 17

Is any provision made for extinguishing fire in generators? If so, describe it.

Answers to Question No. 17. R. A. Hopkins—At present there are a number of methods in use to extinguish fires. Of first importance is differential projection of the generator so that in case of failure the machine will automatically be removed from the line, the steam shut off and the field open. The simplest and most often-used extinguisher is water. This can be applied with a fire hose through a hand hole or by means of a sprinkler pipe within the end bells. The objection to water is that it takes a lot of it and that the machine must be dried out before it can be used, even though the fire damage may be slight. Steam has been used to a slight extent, but due to the necessity of discharging the steam at a distance so that high temperatures will not come into contact with the windings, steam has not been very popular.

A third method has been the use of some inert gas. The small hand extinguisher is often used for small fires. Several stations have installed equipment to discharge CO_2 gas into a machine in the event of fire. This can be done automatically and can be arranged to discharge amounts of CO_2 at given intervals until the fire is extinguished. In using a gas or steam it is necessary to be able to close both the intake and outlet ducts or to have a recirculating system in which the air is used over again and is cooled by a radiator type of cooler. In this closed system, there is only a limited volume of air to support combustion and consequently the system in itself is an effective counter to fire.

R. F. Leefeld—None at Alameda Street Station. CO_2 gas piped into the closed system at Seal Beach.

F. R. Knight—Both machines are equipped with CO_2 protection. Sixteen tanks of CO_2 gas are connected directly into generator air cooling system (closed system). Tanks are discharged electrically by a fusible link, and manually. Six tanks are discharged at once, followed at intervals with two at a time until the whole battery is discharged, or until some one turns it off.

V. E. Johnson—In the main draft tubes for supplying cooling air, a large damper has been installed that can be conveniently closed from the operating floor. This is of course intended to cut off the supply of fresh air in case an arc should start. In addition to this a set of nozzles mounted on a ring of pipe at either end of the generator are so located as to direct a stream of fluid across the fan on the revolving field. This it is intended will throw the stream of fluid against the windings as it normally directs the cooling air against the windings. The piping system is provided with a connection for coupling with the discharge hose from a large pressure tank of tetrachloride, so that the connection can be quickly and conveniently made and the tetrachloride discharged into the windings along the same path as the normal circulation of air for cooling.

C. E. Steinbeck—Water and steam sprays.

L. J. Kraps—All generators are equipped with a CO_2 gas system, which by electrical means gives a timed firing of a sufficient number of tanks of CO_2 gas into the closed air space of the generator to maintain about 30 per cent CO_2 content for thirty minutes. This is supplemented by carbon tetrachloride, and water systems.

E. E. Valk—On all our generators provision is made for the use of either steam or water in case of fires. This consists of a circular duct cast integral with the end shield and provided with numerous jets which direct the flow of liquid directly on the end windings. Suitable piping is brought to the outside of the generator and may be connected either to the water supply or some suitable steam supply according to the wishes of the particular operators.

Question No. 18

What systems of cooling air in generators are used?

Answers to Question No. 18. R. A. Hopkins—Three principal systems for cooling generators are in use today.

(1) The axial system. The air flows from the end bells into the gap between the stator and rotor and also through ducts back of the slots in parallel with the air gap. The air is discharged from these axial ducts and the air gap into a few radial ducts at the center of the machine. From these radial ducts, the air flows away at the back of the machine. This system can be used to advantage on short machines and on machines with relatively shallow stator slots, otherwise the temperature drop becomes too great.

(2) The radial system is the one most in use. All the air enters the air gap and flows radially outward through radial vents distributed along the core. This system is limited to short machines and to machines with not too great air volume, otherwise the air pressure is too great to force the air through the limited space between the stator and rotor.

(3) The multiple radial system is the one commonly used on large turbine generators. The air from the end bells flows in a number of paths in parallel. The air enters the air gap in the usual manner, and also flows into a number of entrance zones at the back of the core. From these entrance zones the air flows inwardly to the air gap, along the gap, and is discharged radially into discharge zones. The advantage of this system is uniform air distribution along the core so

that ventilation no longer limits the strength of machines.

R. F. Leefeld—Free air is circulated at Alameda Street Station. Fin tube heat exchangers are used at Seal Beach, the heat in the circulating air being transferred to the boiler feed water which flows through the inside of the tubes.

F. R. Knight—Closed system of air cooling. Condensate from condenser hot well is circulated through fin type heat exchangers in air circulating chambers where heat from generator is given up to water. A part of feed water system.

V. E. Johnson—Normal atmosphere induced through the fans of the revolving field is used to cool the windings of the generator.

C. E. Steinbeck—See note of answer No. 14.

L. J. Kraps—Air cooling is by means of General Electric fin type coolers.

E. E. Valk—All our turbine generators use a radial system of cooling. In the small units all the air is taken in through the air gap and discharged through radial ducts. On the larger units the air is taken into the air gap and also into sections along the punchings whence it flows radially to the air gap and then out through other sections of the punchings.

Question No. 19

Have you had any experience with air filters? Describe the systems and results of use of them.

Answers to Question No. 19. R. A. Hopkins—Air filters have been used in this country to a great extent. The water spray type has been the one mostly used, although cloth screens and types using a viscous oil are used. The cloth screen has not proven satisfactory because the screens clog with dirt, increasing the air entrance pressure and decreasing the air volume. Either of the other methods is satisfactory although neither will keep a generator as clean as a closed system with an air cooler. When it is remembered that a large turbine generator requires 75,000 cu.ft. of air a minute, it can be seen that if only a small amount of dirt gets through the cleaner, in time the machine will be quite dirty.

R. F. Leefeld—Only with the type where the air supply to the generator is washed and cooled by water sprayed into it. My observation is that this does not clean the air. The evaporation is intense. Most of the particles of dirt are eventually carried into the generator with the air, the moisture in which they were enveloped being evaporated by the high velocity of air.

F. R. Knight—Have had no experience with air filters.

V. E. Johnson—We have not used air filters.

C. E. Steinbeck—We use air washers which require considerable attention to the sprays to keep them clean and efficient. Our new turbine and one of the older ones have been equipped with General Electric cooling units using salt water in a closed system.

L. J. Kraps—No experience with air filters.

E. E. Valk—No.

Question No. 20

What advantages has a steam turbine unit over a Diesel engine driven unit?

Answers to Question No. 20. R. A. Hopkins—A Diesel engine driven machine is necessarily a slow speed machine and cannot, therefore, compete with the high speed turbine generator in weight and floor area required. The cost and efficiency will probably not be much different for the two types of machines. Of course a turbine generator set is not used because the generator is a preferable machine to the Diesel engine driven machine, but because in general, the Diesel engine cannot be built in sizes commensurate with steam turbines. The construction of a turbine generator requires more expensive materials because of the higher stresses and the parts require more machine work.

R. F. Leefeld—Its principal advantage lies in its greater reliability of operation, due to the fact that it can operate for long periods of time without shutting down.

F. R. Knight—Capacity, I should say, is the chief advantage. In small size units I do not believe the turbine can compete with Diesel.

V. E. Johnson—Our experience with Diesel units is limited, but for the average capacity of modern type units, the comparison of control of operation should be very largely in favor of the steam unit, because an equivalent capacity in Diesel engines would consist of several independent units which would largely complicate the operation of the plant as regards governing and controlling. It is probable that the modern Diesel unit could be put under load very quickly if it could be synchronized with the operating system quickly, but the bringing up to speed, synchronizing and loading of several machines would be a complicated operation compared with one large steam unit where delay is necessary on account of tempering and loading.

C. E. Steinbeck—Space requirement per kw. and less upkeep expense.

L. J. Kraps—No experience with Diesel drives. Probably limited capacity of units, larger floor space and excessive maintenance would be principal objections in plants of this size.

E. E. Valk—The Diesel engine has a field of its own but is limited due to the size in which it can be built.

Turbo-Generator Equipment*

Illustrations and a description of the new addition to the Pacific Gas and Electric Company's steam-electric generating plant in Oakland, are given in this report. Also extracts from a report outlining the limitations under which it was necessary to install the new turbine in this plant are given. Operating characteristics of the nine-stage turbine are discussed and illustrated and compared with the seventeen-stage turbine that would have been normal for such an installation.

THE new turbine recently installed at Station "C" of the Pacific Gas and Electric Company at Oakland has been in operation since the middle of October, 1928, and has carried loads up to as high as 43,750 kw. and on many days the total generation has exceeded 1,000,000 kw.-hr. There have been other days when for the whole 24 hours the total generation has only equalled the possible hourly generation for the unit.

The operation of the turbine has been satisfactory in every respect and has more than fulfilled all expectations. It was anticipated that the performance of the unit at maximum output would be at the rate of 440 kw-hr. per bbl. of oil, but the actual performance is 465. At 30,000-kw. output, the efficiency is much better. This is the largest 9-stage machine ever built and for a machine of such few stages this performance is considered very remarkable.

The following extract from a recent paper by R. C. Powell gives very clearly the reason for the selection of the 9-stage machine for the Pacific Gas and Electric system.

> "The plant operates over a wide range of load conditions. At certain seasons it floats with mini-

* Report prepared by C. E. Steinbeck for the turbo-generator equipment subcommittee of the prime movers committee, Engineering Section.

mum load as stand-by to the hydro transmission system. At other times during dry seasons it operates sometimes for considerable periods at full load. The desire to obtain a turbine of largest capacity for the space available and which would have good efficiency at light load led to the selection of a nine-stage impulse turbine. The usual impulse turbine for an output of 42,000 kw. contains seventeen or more stages and the reaction type from 24 to 50 rows of blades, so it is seen that the unit selected is quite a departure from established practice. It is believed to be far the largest nine-stage unit ever built.

"As is well known, the rating of a turbine is more

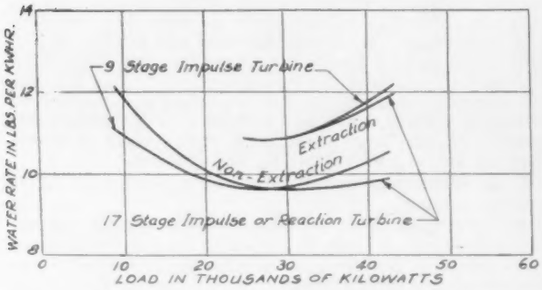

Fig. 1. Water rate of turbine-generators showing comparison between nine-stage impulse turbine and seventeen-stage impulse or reaction turbine.

or less arbitrary and when built to a given frame is rated according to the efficiency desired. When built to a small frame, the no-load steam will be less than for a larger frame and up to a certain load will be more efficient. Beyond this load its efficiency will be less. For the station "C" unit this dividing point is at about 28,000 kw. Up to this point it is more efficient than the conventional unit, but less efficient at higher loads. Taking the water rates on a non-extraction basis, the nine-stage unit does not seem to be altogether acceptable, but it will be seen that extraction for feed water heating helps very nicely over the obstacle of apparently low efficiency at full load. The maximum output finally gets down to the amount of steam that can be passed through the last wheel and the efficiency is reduced by the excessive leaving loss. Furthermore, the flow capacity of the last wheel does not permit the first few stages to be operated at full peripheral flow. Hence, by extracting rather heavily at the higher stages, the flow through the last wheel is reduced, thereby improving the efficiency as well as increasing the capacity.

"The curves in Fig. 1 show the water rates for the nine-stage station "C" turbine in comparison with those for the usual type, for both non-extraction and extraction, with four heaters. The use of four heaters raises the temperature of the feed water to 370 deg. and brings the efficiency of the nine-stage unit to within about 1 per cent of that of the ordinary unit. About $1.50 per kw. was saved in building foundation and in turbine cost by this development."

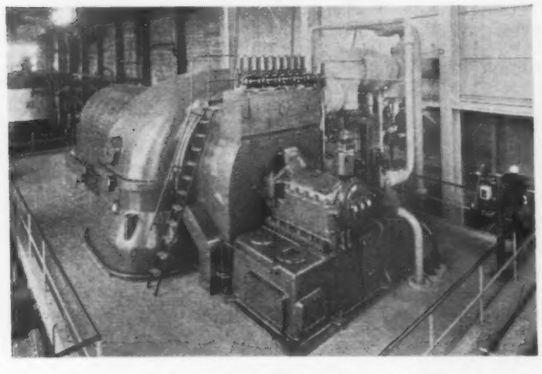

Fig. 2. Turbine-end of nine-stage, 37,500-kw. turbine-generator unit.

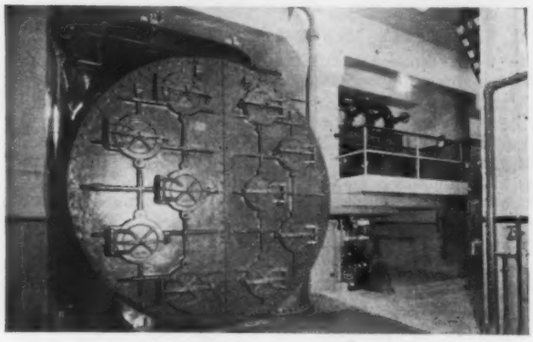

Fig. 3. A view of the air cooler serving the 37,500-kw. generator.

The steam conditions for which the turbine guarantees are given are 425 lb. gage pressure and 700 deg. F. total temperature. The turbine, however, was specified to be designed for 750 deg. temperatures, this temperature being reached under certain operating conditions.

The turbine is provided with a load-limiting device which is intended to hold the turbine from exceeding some predetermined load. This device may be operated either by hand or remote control. A Selsyn indicator is being installed on this device. There also is a bypass added to the valve mechanism so that there always will be enough cooling steam admitted to the turbine when it is floating on the line as a condenser. Figure 2 shows a view of the turbine-end of the unit.

The generator operating at 1,800 r.p.m. was specified at 37,500 kva. at unity power factor. Excitation is at 250 volts and is furnished by a 140-kw. exciter. Stand-by for this exciter is provided by a separate motor-driven exciter.

The generator is cooled by closed systems of air circulation. Figure 3 shows a view of the air cooler. The generator requires 85,000 cu.ft. of air per minute. Salt water is used for cooling and is obtained by piping the air coolers in parallel with the main condenser circulating water system without any pump on the air cooler

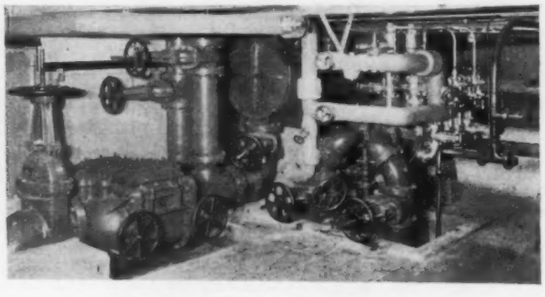

Fig. 4. Strainer in cooling water line.

cooling water system. A strainer is provided on this cooler line to remove any growth which might fall off the piping between the pumps and the coolers, the pumps being at a considerable distance from the turbine.

Figure 4 shows a view of the strainer mentioned in the preceding paragraph, also the condenser air cooler, and the steam jet air pumps. The condenser has a surface of 28,000 sq.ft. with a separate air cooler of 2,000 sq.ft. The condenser is a single-pass divided-water-box unit. This apparatus as arranged has proved very efficient. With a load of 42,750 kw. on the turbine and 54 deg. F. inlet circulating water the condenser has developed a vacuum of 29.05 in. of mercury when the barometer was 30.04 in. The condenser was designed for 60,000 gal. of water per minute. A motor-driven vacuum pump has been ordered to connect in parallel with the steam-jet air pumps. This pump will be used in starting up and for testing when no steam is available.

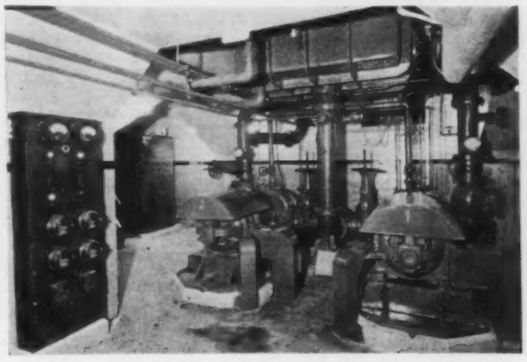

Fig. 5. Condensate pumps driven by variable-speed motors.

The condensate pumps shown in Fig. 5 are driven by variable speed motors and the motor speeds are controlled by floats connected to the condenser hotwell. As the water rises in the hotwell the float operates a control switch which speeds up the motor thus handling automatically any variation in load on the turbine. A Selsyn indicator is provided on this switch at the operating engineer's desk. There also is provided hand control for these switches.

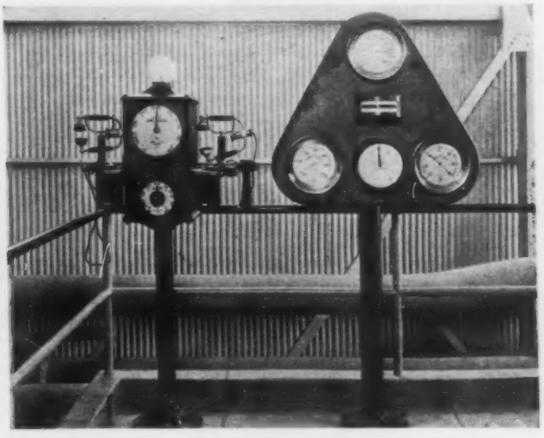

Fig. 6. Instrument board on turbine platform. This equipment appears also at the extreme right in Fig. 2.

A view of the instrument board is shown in Fig. 6. These instruments are connected with the switchboard, which is located in a separate building.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

UNDERGROUND SYSTEMS COMMITTEE REPORTS[2]

Reliability of High-Voltage Cables in Operation

By E. R. STAUFFACHER*

A treatise descriptive of the reliability of lead-covered cables operating at voltages from 6.6 to 132 kv. with tables giving miles of cable in use, number of failures per year and causes of failure. The information was gathered from records including the entire country.

THE record of extra-high voltage cables in service is encouraging. Although there is yet much work to be done and a number of problems to be solved it appears that the application of extra-high voltage cable has passed through probably the most severe stage of experimentation. There is every reason to expect that before long the record for reliability will be comparable with overhead high-voltage transmission lines.

Few, if any, installations of extra-high voltage cable have been made in the West and hence it is necessary to refer to the East to obtain performance records of such cable. Fortunately, this information has been compiled through a cammittee of the N.E.L.A., such committee working in conjunction with the Association of Edison Illuminating Companies. Most of the information contained in this report is compiled from those two sources. Information has been obtained from the

* Report prepared for the underground systems committee, Engineering Section.

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TABLE I—Operating record of 33-kv. three-conductor cable as reported by the Los Angeles Bureau of Power & Light.

No. of Miles	Type of Cable	Failures during 1928
12	Belted	13 in cable 1 in joint
2.25	Shielded	None to date

Note:—Failures during 1928 were approximately 50 per cent more than in 1927.

greater portion of the operating companies in the country, but there are a few companies which did not report and consequently their experience could not be noted.

Outstanding features of the operating record of extra-high voltage cable in service are:

1. The 132-kv. lines in New York and Chicago, totaling 53 miles of cable, have not experienced a single electrical failure in more than a year of service. Neither installation, however, has yet (Jan. 1, 1929) carried its rated load. In some cases a few oil leaks have developed, but these leaks have not interfered with the use of the line. It has been possible to continue the use of the cable under this condition until convenient to take the line out of service for the necessary repairs.

2. Operating records for 66-kv. cable appear to be improving. The 66-kv. installation in Cleveland, amounting to 50 miles, shows a better record this year (1928). There were only three failures this year against seven reported a year ago and 22 two years ago. Records of 66-kv. cable installed in Philadelphia in 1926, amounting to 23 miles, show two failures during 1928 against none reported for 1927 and ten reported for 1926. The second (1927) installation of 66-kv. cable in Philadelphia, amounting to approximately 36 miles, had eight failures during 1928 as against twelve reported during 1927. Chicago reported three failures during 1928 on an installation of 44 miles of 66-kv. cable against seven failures during 1927. In addition to this, Chicago and Philadelphia have installed a total of nearly 60 miles of cable during 1928 and so far as is known, there has been only one failure so far. (Jan. 1, 1929.)

3. The 44-kv. single-conductor cable in New York shows a confusing record for the year. In 21 miles of one make of cable there has not been a single failure in nearly four years of operation, while in 45 miles of another make eight failures were reported during 1928 as against four failures during 1927.

The question of maximum permissible operating temperature probably is the outstanding problem to be considered. The permissible operating temperature in

TABLE II—Operating record of 16.5-kv. cable as reported by the Los Angeles Gas & Electric Corporation.

Miles of Cable	Date	Failures
14.71 17.90 19.60	Jan. 1, 1927 Jan. 1, 1928 Jan. 1, 1929	One only between Jan. 1, 1927 and Jan. 1, 1929.

Note:—The one failure occurred in a splice between three single-conductor cables and a three-conductor cable where it entered a pothead riser. Probably was due to an improperly made splice.

cables appears to be a function of several factors, including the actual temperature and the various effects of temperature change. There have been no indications that the conductor is a vital factor in determining the maximum allowable temperature, for it must be remembered that low-tension cable has been known to operate above 100 deg. C. without evidence of mechanical change in the conductors which would result in denting the insulation and increasing the maximum stresses. Information available at present regarding impregnating compound indicates that ionization probably is the outstanding factor in cable deterioration and it must be remembered that ionization is a strictly electrical function which is not directly affected a great deal by heating.

It is probable that the effects of temperature changes are a much more important factor in the life of cables than the actual maximum temperature. There does not appear to be much evidence indicating that temperature changes, as such, affect either the copper or the paper. The greatest difficulty due to temperature change seems to come from the fact that all ordinary impregnating compounds have coefficients of temperature expansion enormously higher than that of lead. It is probable that this expansion develops pressure high enough to stretch the lead and later appreciable voids or vacua might be developed upon cooling. If a vacuum is developed ionization will be increased greatly and possibly cause objectionable reaction in the impregnating compounds and paper insulation. A greater cycle of temperature or, in other words, an increased temperature change means an increased longitudinal expansion and contraction of the cable. This effect is most noticeable at duct-ends where the sheath tends to wear seriously unless the cable is properly supported through the manhole. This also makes it imperative that short bends in the manholes be eliminated in order to prevent the sheath cracking at those points.

Operating experience available at the present time, indicates that throughout a certain range of conductor

TABLE III—Three-year record of cable and cable-joint failures as compiled from N. E. L. A. data covering cables in the 6.6—132-kv. class.

Item	1927	1926	1925
Number of Companies reporting	43	41	36
Total miles of cable	10,617	9,236	8,821
Total cable failures	916	949	823
Total number of joints	203,293	178,852	169,233
Total joint failures	555	582	486
Total cable and joint failures	1,471	1,531	1,309
Total cable failures per 100 miles of cable	8.62	10.28	9.32
Total joint failures per 1000 joints	2.73	3.26	2.87
Total cable and joint failures per 100 miles of cable	13.88	16.60	14.80
*Cable failures due to internal and electrical causes	222	267	230
Cable failures per 100 miles of cable due to internal and electrical causes	2.09	2.89	2.61

***Note:**—Internal and electrical causes of cable failures may be segregated as follows:
(a) Overheating of cable due to high dielectric loss in insulation.
(b) Deterioration of old insulation and obsolete style of joint.
(c) Defective cable material.
(d) Defective cable workmanship.
(e) Due to formation of "X" in cable without evidence of ionization. This baffling problem of the causes and effect of the formation of solid matter, known as "X," in the compound in impregnated paper-insulated cable after its being in service for some time, is still to be solved. It is charged with the responsibility of causing some of the cable failures.
(f) Due to ionization of cable without formation of "X."
(g) Due to ionization with formation of "X."

temperatures the cable will operate satisfactorily, but it also indicates that if the temperatures are much higher the life of the cable is reduced to a comparatively short time. At the present time it is impossible to state definitely the temperature based on operating experience beyond which the life of the cable is shortened materially. Apparently a great deal of study must be devoted to the various factors entering into the problem before a reliable basis for determining the maximum allowable operating temperature of cable can be fixed.

Sheath losses in single-conductor cable must be given careful attention if such cable is intended to transmit larger amounts of power. These losses have not proved to be as great a handicap as was expected and it has been shown that they may be kept within economic limits where the use of preventive measures is

TABLE IV—Failures of cables in service. A general classification covering 7.5—30-kv. cables compiled from data supplied by the Association of Edison Illuminating Companies.

Cause of Failure	1928 Number	1928 Per Cent	1927 Number	1927 Per Cent
Definite causes other than those inherent in cable	335	62.5	33	36.0
Inherent in cable, such as poor quality of materials or manufacturing defects	139	26.0	42	45.0
Unknown causes	62	11.5	18	19.0

adopted, such as some form of sheath-insulating joints which are not unduly elaborate.

Although there are many problems yet to be solved, there appears to be an increased demand for high-

voltage single-conductor cable, particularly for voltages around 75 kv. and with conductors of approximately 1,000,000 circ.mil. The successful operation of the oil-filled 132-kv. cables in New York and Chicago has directed attention to the advantages of similar methods applied to multi-conductor cable. It is interesting to note that the first installation of three-conductor 350,000-circ.mil, 35-kv. cable of the oil-filled type now is being made.

Multi-conductor cable with shielded conductors is being more extensively utilized. It appears that this particular type of conductor cable will predominate for higher voltage transmission. Also, in view of the continued success of cable made with wood-pulp paper, this practice now may be considered as thoroughly established.

Probably the outstanding user of medium-high voltage cable in southern California is the Los Angeles Bureau of Power and Light. Information furnished by that organization covering the operation of its 33-kv. belted-type cable as well as the installation of shielded-type cable is given in Table I. Although the Bureau has had a rather high number of failures compared to the number of miles of cable, it is pointed out by the engineers of the Bureau that this cable has been working hard and that there has been no opportunity to favor it in any way. It had to take the load as it came and consequently has undergone the most severe service.

Table II covers the performance of the Los Angeles Gas and Electric Corporation's high-voltage cables.

From information submitted by the N.E.L.A. underground systems committee the performance of cables and joints for the past three years in the 6.6—132-kv. class may be studied. This information is submitted in this report in Table III.

Tables IV, V, and VI were made up from information submitted by the Association of Edison Illuminating Companies and cover a classification of cables which might be termed "medium voltage," that is, between 7.5 and 30 kv. This information was compiled from the operating records of a fewer number of companies than was the case in the report submitted by the N.E.L.A., but it is felt that the information is sufficiently complete to indicate definitely the trend of operating experience with this classification of cable.

It is believed that available evidence indicates that there has been a consistent improvement in the quality of cable for the past several years. As may be noted from the tables, many of the recorded failures are due to causes which can be eliminated by the operating companies. It is unnecessary to urge the great value of carefully compiled operating records of cable performance and it is suggested that in addition to records of cable failures it might be well and quite illuminating to include the amount of power in kilowatt-hours successfully transmitted per year by modern high-voltage cables.

TABLE V—Classification of cable failures attributed to causes other than those inherent in the cable. Tabulation covers 7.5—30-kv. cables. Compiled from data supplied by the Association of Edison Illuminating Companies covering the period from April 1, 1927 to July 1, 1928.

Cause	Failures Number	Per Cent
Electrolysis and chemical corrosion of sheath	61	18.2
Expansion, contraction or vibration	30	8.9
Wear at edge of duct or hangers	31	9.3
Broken sheath due to mechanical injury from excessive pulling tension or from unknown cause	11	3.3
Failure of adjacent cable	10	3.0
Overload and lightning	3	1.0
Overheating from external cause	4	1.2
Moisture in cable and draining of compound	4	1.2
Mechanical injury either during or after installation	180	54.0
Excessive test voltage	1	0.3
Total	335	100.0

TABLE VI—Classification of cable failures attributed to causes inherent in the cable. Tabulation covers 7.5—30-kv. cables. Compiled from data supplied by the Association of Edison Illuminating Companies covering the period from April 1, 1927 to July 1, 1928.

Cause	Failures Number	Per Cent
Wrinkles in insulation	87	43.0
Torn tapes	5	2.5
Soft insulation	1	3.0
Ionization or dielectric loss	43	21.2
Defects in lead sheath	6	3.0
Registration of tapes	10	5.0
Formation of solid matter "X" in the compound in impregnated-paper insulation	45	22.3
Total	197	100.0

Note:—Although there were only 139 cases of failure, more than one possible cause of failure was found in many cases.

Underground Systems in Real Estate Subdivisions

By C. E. BIGGS*

Many systems are installed in high class subdivisions. Combination telephone and electric subways date back to 1911 and 1912. Subway construction of various companies is very similar but cable requirements differ. Ample conduit size should be provided as residence loads are increasing rapidly.

IN SOUTHERN California, underground installations are recognized as essential in the better class of subdivision or residential area. Although subdividers, contractors and operating companies are beginning to give more attention than ever before to methods of installation, underground residential service by no means is a new departure. In fact, combination telephone and electric underground construction of as early as 1911 and 1912 is a matter of record. Some of these first installations are still in use. Most of them, however, have been rebuilt because the original construction was poor both in material and plan and the cables inadequate to meet growing demands of residential cooking and heating.

The Southern California Edison Company has about a hundred isolated underground installations in residential areas. The installations range in size from a single manhole or vault to 130 manholes and vaults. In most cases joint telephone and electric installations were made. A review of the systems of the several companies serving underground areas on the Pacific Coast shows that while there is a difference in cable requirements, the construction details of manholes, vaults, main duct lines and laterals are practically the same. Undoubtedly the standard design used by the Edison Company in joint telephone and electric distribution is as nearly a typical specification as can be produced. Residential underground distribution system construction also has been standardized as far as general practice goes. In some cases the systems are installed complete when the tracts are opened and in others the extensions are mads as the sale of property demands.

Regardless of the identity of the duct-system builders, cables always are installed by the Southern California Edison Company, as this practice seems more satisfactory to all concerned.

In laying out an underground system in a high class subdivision it is well to provide conduit of ample size, especially service laterals leading from manholes to lots. The demand of the modern house exceeds anything ex-

* Report prepared for the underground systems committee, Engineering Section.

perienced in the past and is increasing yearly. In 1911 and 1912 a No. 2 main-line secondary was considered ample and a 1-in. lateral conduit with two or three No. 6 wires to the house switch supplied all the service required. Service lateral conduit was increased later to 1¼ in., then to a minimum of 1½ in. and at present it is established practice to ask for a minimum of 2-in. conduit for runs of 100 ft or less and a minimum of 2½-in. conduit for all runs of more than 100 ft. Main-line secondary cables now seldom are less than 2/0.

Cable Fireproofing

By Z. T. PETTIT*

Shows the necessity for protecting cables from damage due to fire in adjacent cables. Discusses the class of cable by voltage which should be fireproofed, the different kinds and methods of application.

THE electric utility is confronted with the problem of limiting the extent of damage caused by breakdown in underground cables. The extent of damage to the cable in trouble obviously is a problem of electrical protective devices and will not be discussed in this paper. However, the means at hand for preventing the outbreak from damaging adjacent equipment and cables will be discussed together with their attendant advantages and disadvantages as encountered in practical application.

It seems to be the consensus of opinion among the member companies of the Pacific Coast Electrical Association, that some form of "fireproofing" is the solution. From the reports returned on a questionnaire sent to all member companies having underground systems it is found that all the different types of fireproofing used have, in their protective way, served the purpose. The following paragraphs give certain data gathered from the questionnaires:

A few of the reporting companies fireproof only cables carrying voltages of 11 kv. or higher. Others fireproof cables of 2.3 kv. and up, while the more cautious companies fireproof all cables in congested manholes, although in less congested manholes the secondary (110/220-volt) cables are omitted.

On those systems where 220- or 500-volt d.c. cables still are prevalent they usually are fireproofed and treated the same as cables of higher voltage.

One material that has been used is concrete with rope, burlap, or metal-lath carrier. This form has some very distinctive disadvantages in that it sets up very rigidly and is extremely brittle. An accidental blow will crack and shatter the concrete leaving the enclosed cable practically exposed. There are cases on record where the explosiveness of the short-circuit shattered the concrete on the cable in trouble as well as that on adjacent cables, causing damage to several feeders in the immediate vicinity of the breakdown. Another disadvantage encountered in this type is that the rigidity of the set does not make provision for expansion and contraction, thus causing abrasion of the lead sheath. However, there are cases on record where fireproofing of concrete over rope carrier saved cable from damage during a severe short-circuit and the resulting intense heat.

One company uses a type of fireproofing that consists of precast concrete tile split in half. This tile is clamped over the cable after the splice is made. The walls of the tile are 1 in. thick and the sections are 12 in. long, the assembled unit being about 12 in. in outside diameter. This is used only in manholes that are constructed for high-tension cables.

The type of fireproofing that seems to be more generally favored is that of asbestos tape, either immersed in sodium silicate to cause it to harden or covered with "asbestoment" cement. It is believed that this cement is superior to sodium silicate due to the fact that the sodium compound sets to a brittle hardness and does not have the added protection of the extra layer as in the case where asbestoment is used. The asbestos type with asbestoment covering does not become brittle, but forms a comparatively tough covering that will withstand ordinary mechanical injury. This type may be built to any desired thickness by applying successive layers, but a thickness of from ¼ to ½ in. seems to be sufficient. The ease and speed of application of this material can be understood readily from the fact that the asbestos comes in small rolls and is applied in the same manner as tape. The covering of asbestoment is applied with the hands, using old, defective rubber gloves to protect the hands.

One very important consideration in connection with fireproofing is that of duct ventilation and cable creepage. Most of the companies stop the fireproofing from ½ to 2 in. back from the end of the duct in order not to interfere with ventilation or make a rigid connection between duct and fireproofing. The most advisable plan, especially to those contemplating a new underground system or the rebuilding of old conduit, is to give the ducts entering the manhole as much separation as is possible. The whole layout should be planned and the cable racked in such a manner as to facilitate fireproofing. One company has found it necessary to make a complete change in cable racking equipment in order to accommodate fireproofing. The saddle type of insulator was found to be best suited to the purpose.

There seems to be a diversity of opinion as to what crew should apply the fireproofing. Some companies have the splicers apply the covering after completing the splice, while others have specially trained men who do nothing but fireproofing. It is the opinion of the underground engineers of the Los Angeles Gas and Electric Corporation that, whoever does the work, considerable effort should be exerted to insure care and exactness in the original application of fireproofing material and to assure a careful check to ascertain that fireproofing is replaced after being taken off for inspection or repair work on cables.

* Report prepared for the underground systems committee, Engineering Section.

Cable Installation Methods

By C. G. MANSFIELD*

Describes transportation equipment and methods used for both pulling in and pulling out lead covered cables and the kinds of lubricants used. Describes various kinds of cable racks for use in manholes, and their application. Shows methods of making splices for both low and high tension cables.

THE following summary of cable installation methods is based upon questionnaire returns received from six companies in the Pacific Coast territory which operate underground cable installations of appreciable extent. Practice seems to be fairly well standardized, and no outstanding recent developments are to be noted.

Transportation and Pulling

Special two- or four-wheel trailers for moving cable reels to the point of installation are used generally. The reel is supported on a shaft in such a way that it may be rotated easily as the cable is drawn into the duct. When more reels than can be mounted on one trailer

* Report prepared for the underground systems committee, Engineering Section.

are to be used in the same location, they are transported on a special low bed trailer, or in some cases, on a low section built into the pulling truck. Reels too large for any available cable trailer are moved by other means and set up on jacks while the cable is being pulled in. While this method is somewhat cumbersome, it is satisfactory where the number of such large reels to be handled would not justify the purchase and maintenance of a special trailer. Only one company reports no use of the cable trailer. In this case arrangements are made on all major jobs to have the cable delivered at the point of installation. On smaller jobs the reels are transported on the pulling truck or ordinary trailers.

Four types of pulling equipment may be noted, showing various degrees of specialization. The first consists of a power winch mounted on a truck of more or less conventional design. The sides of the body are subdivided into locker space for tools and supplies, leaving a central aisle for the men and any special equipment or materials needed on the job. The pulling line passes over a sheave at the back of the truck platform when pulling cables, but also may be placed over a sheave mounted on a tripod at the top of the truck for handling transformers or other heavy equipment. Nigger-heads are provided on the ends of the winch for use in pulling the lighter cables with a rope. Two companies report the use of this type. A low-bed truck with a winch mounted near the forward end is used by one company. A moderate amount of locker space is provided above the running board and the space between the winch and the rear wheels is used for carrying reels. Two companies use power winches mounted on tractors, while one uses a hand operated winch mounted in a frame which is set up directly over the manhole head.

Steel lines are used for the heavy pulls, but a manila rope is used with the hand-operated winch and for easy pulls with the power winches. Small service runs are pulled by hand. In the newer installations, pulling irons are built into the manhole walls for attachment of the block over which the pulling line runs. In some of the older manholes still in service no such irons were provided and it is necessary to erect a temporary wooden frame to support the block.

The use of woven-steel cable grips or "baskets" is quite general on all except the largest sizes. For exceptionally hard pulls some form of cable "nose" is attached directly to the conductors of the cable. Where two or more cables are to be pulled into the same duct, a pulling eye sometimes is formed by weaving together and wiping the exposed conductors. Cables to be pulled in together are either cut to length and wound together on a spare reel in the warehouse, or fed into the manhole simultaneously from separate reels.

When cable is removed for re-installation special precautions are taken to prevent damage to the sheath. One company takes the cable out with a continuous pull, using a brass funnel at the duct mouth and a smooth hardwood block at the edge of the manhole head. Another pulls the cable over two large wood sheaves mounted on a frame which is set down into the manhole. Others make a series of short pulls, using a grip made up of unraveled rope and taking up the cable on a spare reel as it is pulled out. This method is particularly suitable where traffic conditions do not permit laying the entire length of cable out in the street. In removing cables after failure, some companies attach a rope to the trailing end so that it may be recovered in case the cable breaks at the point of failure.

All of the reporting companies use heavy grease to lubricate cables being pulled in, although some small cables are pulled without lubrication. For pulling rubber-covered wires into iron conduit one company uses mica powder, while another finds soapstone more satisfactory. Two or three other lubricating materials are being tried out but no definite results are as yet available. One company reports a reduction in pulling stress of as much as 20 or 25 per cent due to the use of grease on the cables.

Racking and Jointing

Three of the reporting companies support cables on factory-made cable racks consisting of vertically adjustable brackets and grooved porcelain blocks. Two companies use grooved wood blocks supported on 1-in. iron pipes inserted in holes in the manhole walls or attached to the ceiling and one company uses similar wood blocks bolted to a pair of steel bars mounted vertically on the wall. On vertical runs of large cable longer than 6 ft., one company provides a support by wiping a ring of metal to the sheath and supporting it on wood blocks. No special provisions are made for taking care of expansion and contraction, other than the offsets which normally occur in training the cables around the manhole walls, and the use of lead shields at the duct mouth. Bends close to the duct mouth are avoided.

Splices in secondary cables are made up of standard copper connectors, oiled or varnished cambric tape (to a thickness somewhat greater than the factory paper), and standard sizes of lead sleeving. On primary cables, two companies use taped splices similar to, but longer than splices used on secondary cables; two companies use taped splices with the addition of a "conducell" barrier, while one company uses a taped splice on primary "Y" connections and a "conducell" without taping in the straight three-conductor splices. Primary and secondary splices usually are filled with No. 150 Ozite compound. One company uses paraffin in the secondary splices.

On cables of the usual primary and secondary voltages a splice which is well proportioned and well made from the mechanical point of view usually will have ample electrical strength, and no features of special interest are apparent in its design. It is generally recognized, however, that in joints for cables of the higher voltages used in transmission lines the electrical characteristics become of vital importance, and that a satisfactory joint does not necessarily result from the mere proportional enlargement of a type which has proved successful for lower voltages. Hence these high-voltage joints either are very carefully proportioned to obtain the most desirable stress distribution, or are built from materials and to specifications furnished by the cable manufacturer. The problem of joint design is considerably simplified by the use of the shielded or type "H" cables now being used for the higher voltages.

Only the most careful and experienced splicers are assigned to work on the high-voltage joints and special care is taken to exclude all dirt and moisture during the progress of the work. If the joint is not completed in one day the insulation is protected by a temporary shell until the following day. These joints usually are filled with a softer grease or oil similar to that with which the cable is impregnated. On some recent installations of 33-kv. cables, the joints are being filled with pure, high-grade transil oil. This is in line with the modern tendency toward the use of less viscous oils in the higher voltage cables.

None of the reporting companies maintain a regular school for splicers. The necessary supply of trained men is obtained by the regular advancement of helpers or apprentices. Splicers' tool equipment is standardized quite generally, although one company requires each splicer to furnish his own tools. Tools are transported in special carts, some of which are arranged to be pushed by hand, and some to be towed behind an automobile. One company uses a cart permanently attached to a motorcycle. In outlying districts, a light truck sometimes is used instead of the usual cart.

Practically all primary and transmission cables are protected in the manholes with a covering of "niagrite" tape saturated with "asbestoment" or sodium silicate. Similar protection is applied on all cables in some of the more congested manholes, and by one company, on all d.c. cables. One company uses a concrete tile housing on the transmission cables.

Underground Work During Daylight Hours

By E. R. NORTHMORE*

A discussion of the problem of the installation of subways and cables at a minimum cost and with the least interference with motor traffic in congested areas. Discussion touches upon night work versus daytime work in congested streets.

A TREMENDOUS increase in motor traffic on streets of growing cities has introduced a problem and in some locations made it necessary to clear the streets of traffic obstructions to keep the traffic moving during the busy part of the day, from 8 a.m. to 7 p.m. As the growth of a city and its business conditions depend largely upon the traffic situation, it is of paramount importance to relieve as much as possible any congestion. Every utility has an obligation to make the city in which it operates a progressive one.

With the above problems in mind, there are (first) the city officials who say, "When can improvements be installed in city streets with the least traffic interference," and (second) the public utility management which says, "When can facilities be installed at a minimum cost, with as little complaint as possible?"

From data collected through the P.C.E.A. it is found that not all of the companies are seriously affected by traffic interfering with normal working routine. Nevertheless, the need of a remedy is generally recognized for, as traffic congestion increases, construction and operating costs are found to increase rapidly due to the difficulty in delivering and removing materials, the time lost in waiting for traffic, crowded working space, additional necessary safety measures and the reaction from the public and traffic officers who say, "Why don't you do this work at night?"

While none of our cities have passed ordinances compelling the utilities to work in the congested area only at night, it seems apparent that such laws must inevitably face the utility unless the utility does everything possible to aid the city officials in keeping congested streets clear during the crowded periods of the day.

In Los Angeles this class of utility construction is being done under rules issued by the Board of Public Works. These require that on certain busy corners and in several blocks of a certain particularly busy street, work shall be done only between 7 p.m. and 7 a.m. The Los Angeles Gas and Electric Corporation uses heavy steel plates to cover all excavations between 7 a.m. and 7 p.m. Further, all dirt, gravel, tool boxes and other material is removed from the street during the restricted period. In part of the business district it is required that three shifts be worked on all jobs to expedite completion of construction work and attendant traffic interference.

During the month of December utilities are not allowed to make any excavations in the business district and are allowed to open manholes only at night, except in case of emergency. Thus it is obvious that utilities gradually are being forced to do street work at night.

The underground department of the Los Angeles Gas and Electric Corporation works from 7 a.m. to 4 p.m., thus aiding traffic and also allowing crews to get located with their carts and the men to be at work before the 8 o'clock morning traffic rush. Further, these working hours take them off the street before the 5 p.m. rush. These conditions make it necessary gradually to do more night work, and it is believed that within a few years most underground work in congested areas will be done nights and Sundays.

The City of Los Angeles has an organization copied after the Joint Pole Committee. This organization is called the "Sub-structure Committee," and includes in its membership a representative from each of the electrical, communication, gas, railway, water and other public utilities; also a representative from the municipal street lighting department and the city engineer's department.

This committee meets monthly and has accomplished a great deal of good by planning all future work, allocating a part of the street to each utility and working to relieve the traffic congestion on the street as much as possible during construction. Some other cities have an organization similar to this and it is believed that such organizations are well justified, saving money for utilities and keeping the utilities and municipalities in closer touch with one another.

* Report prepared for the underground systems committee, Engineering Section.

Reliable Measurement of Manhole and Duct Temperatures

By C. B. JUDSON*

Recommends systematic investigations of temperature and describes methods of making such tests in transformers and vaults, ducts and manholes.

TEMPERATURES are the ultimate limiting factor as to load and output in practically all modern electric equipment. Therefore the checking and measurement of temperatures in underground systems should be of special interest to all companies having any extended systems. Information gathered from most of the P.C.E.A. member companies having underground systems in California leads to the conclusion that most of these companies are not making any systematic temperature survey. It is generally realized that the ill effects of overheating cables and other apparatus if allowed to continue over long periods of time, will be a cause of equipment failure. Such ill effects include decrease in current carrying capacity, increase of power loss and, in case the heating becomes severe enough, a very rapid deterioration of insulation.

Transformer and Vault Temperatures

Transformer and vault temperatures are considered together because from the information received it is apparent that all member companies check vault temperatures at the same time that transformer loads and temperatures are checked. This is the practice of the Los Angeles Gas and Electric Corporation and it is believed to be the logical time for such a check.

Procedure in checking generally consists of the measurement of loads one or more times each year during heavy-load periods by means of split-core transformers together with either recording or indicating ammeters. It is well not to put much faith in indicating-meter tests as accuracy favors the 24-hour check. This latter gives not only the maximum load, but gives also the time duration of the load and it is both of these factors which govern the heating of equipment. Several companies mention the use of some form of transformer temperature indicators of which there are several on the market. In conjunction with these, one member

* Report prepared for the underground systems committee, Engineering Section.

uses a glass "maximum" thermometer near the coils to locate hot spots. At the same time a maximum thermometer is installed in the vault to give corresponding vault temperatures.

The practice of the Los Angeles Gas and Electric Corporation is to equip all underground transformers with load indicators. For the determination of vault temperatures a "maximum-minimum" thermometer is used and on the load checks two split-core transformers (one on each leg) together with recording meters are used. This gives an indication of load balance as well as a measure of the actual load. These readings are all recorded on transformer load cards which also carry the approximate connected load at time of test. These cards are watched and when any transformer shows a sufficient increase in connected load it is checked again. It is company practice to check all underground transformers once each year. When a hot vault is found a recording thermometer is installed This is a liquid-type instrument having a 65-ft. cable. Its accuracy is within ½ deg. Splicers and trouble men are all instructed to report all hot vaults and all load indicators which have their "tongues hanging out." These practices have proved very satisfactory in the case of the Los Angeles Gas and Electric Corporation.

Duct and Manhole Temperatures

There seems to be more difference of opinion as to the best method of conducting tests designed to obtain data as to duct and manhole temperatures. The general report from most companies is that no regular check of these is made, except in some special isolated cases. The practice seems to be to keep a close check of the loads carried by the respective cables. This, from the experience of the Los Angeles Gas and Electric Corporation, works out very well.

There are several methods for measuring duct and cable temperatures. One company reports the use of thermocouples attached to the station-end of the cables before they are pulled into the ducts. These thermocouples are checked at stated intervals, a system that is very good, but which cannot be used in a system already installed. Another company reports a special 33-kv. cable-way which is equipped with resistance-type measuring units embedded in the concrete at several points and other units which are attached to the cables at the same locations. Readings are taken on these units several times a year. This system is very good in these special cases, but it is not possible to install it on existing systems.

Space and time prohibit adequate treatment of the subject of cable temperatures and hence the reader is referred to the 1927 Proceedings of the Pacific Coast Electrical Association and specifically to the article on page 272 of that volume entitled, "The Determination of Temperatures in Underground Cables," by G. L. Hill. This is one of the best articles on the subject that has been found. Mr. Hill determined from his tests that it is not necessary to measure the temperature more than 10 or 12 ft. from the duct entrance as the temperature curve is practically a straight line between these points. This greatly simplifies the matter of getting duct temperatures. From reading Mr. Hill's report it is believed that the thermocouple method is to be recommended. Other schemes such as the resistance method and the mercury or other liquid-type thermometers lend themselves better to general surveys than to routine tests or checks as referred to in the transformer and vault section of this paper.

The Los Angeles Gas and Electric Corporation has not made any special tests as to duct temperatures except in one local section near one of its steam plants where there is a very large number of cables. These tests were carried on with the use of a recording meter supplemented with several maximum thermometers.

Re-Use of Withdrawn Cable

By G. L. HILL*

A summary of the practice of Pacific Coast and Eastern utilities in determining what disposition shall be made of cables after they have been withdrawn from the ducts, how inspected and tested, at what voltages they may be used again and specifications for the making of splices which may be drawn into the ducts so that short pieces may be used up. Figures showing economy of making duct splices.

LEAD-COVERED underground cable is being used in rapidly increasing amounts on the Pacific Coast. For this reason the question of what to do with short pieces and full lengths of withdrawn cable becomes a problem of importance.

It is the object of this paper to give a summary of a survey made covering this subject so that the Pacific Coast Electrical Association members may be informed as to what has been accomplished along this line. The paper includes data taken from questionnaires sent to fourteen of the Eastern and Middle Western companies, to P.C.E.A. members and to the Metropolitan Section, (New York) N.E.L.A.

Answers have been summarized according to the following outline:

(a) Re-use of full reel lengths or long pieces of cable not requiring a duct splice.

(b) Salvaging short pieces of cable by duct splicing them together.

Re-use of Full Reel Lengths or Long Pieces of Cable Not Requiring a Duct Splice

Where cable is re-used the various companies reinstall it for use at the voltages indicated in the following outline:

Eastern and Middle Western Companies—Twenty-one per cent of the companies re-use withdrawn cable of all voltages at the original voltage.

Twenty-eight per cent of the companies re-use withdrawn cable up to and including 13 kv.

Fourteen percent of the companies re-use withdrawn cable up to and including 11 kv.

Fourteen per cent of the companies re-use withdrawn cable at its original voltage up to and including 4 kv.

Another company re-uses withdrawn cable at its original voltage up to and including 22 kv.

One company re-uses withdrawn cable at its original voltage up to and including 2.4 kv.

Another company contemplates re-using cable at its original voltage up to and including 13 kv.

P.C.E.A. Companies—One company states it considers that cable formerly used for from 15 to 35 kv. is not electrically safe for re-use at that voltage. That company has re-used considerable 4-kv. cable without any breakdowns.

Another company reports that if cable passes test O.K. it is sealed, tagged and coiled, and placed in stock as good cable to be sent out for service at its original rated voltage.

A third company states that it uses cables of odd sizes at rated voltages or in secondary service if a suitable location can be selected. Such cable as cannot be used in special locations is scrapped.

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* Report prepared for the underground systems committee, Engineering Section.

Answering the question, "Has your experience justified the use of re-used cable at the original voltage?" the following outline is offered:

Eastern and Middle Western Companies—Twenty-one per cent of the companies feel justified in re-using cable of all voltages at its original voltage.

Twenty-eight per cent of the companies feel justified in re-using cable of all voltages at its original voltage up to and including 13 kv.

Fourteen per cent of the companies feel justified in re-using cable at its original voltage up to and including 11 kv.

Fourteen per cent of the companies feel justified in re-using cable at its original voltage up to and including 4 kv.

One company feels justified in re-using cable at its original voltage up to and including 22 kv.

(c) Various tests, electrical and otherwise, used to determine whether or not the cable in question is satisfactory to use again and whether or not it should be re-used in service at the same voltage for which originally purchased or in some lower voltage service are indicated in the following outline:

Eastern and Middle Western Companies—Thirty-five per cent of the companies answering this question give the cable only a visual examination before re-installation.

One gives the cable a Megger test after re-installation.

Fifty-eight per cent of the companies use electrical tests, shown as follows:

One company tests the cable in accordance with standard N.E.L.A. and A.I.E.E. specifications.

Another company uses a standard Kenetron test and a physical examination.

A third company tests all cables for five minutes at 80 per cent of "test of installation" prescribed in cable specifications and gives all rubber insulated cables a mechanical test at 80 per cent of the factory test.

A fourth company tests cable to be re-used at 27 kv. for five minutes at 95 kv. d.c. (Kenetron) from phase to ground and 135 kv. d.c. (Kenetron) from phase to phase. After installation it is tested at 95 kv. d.c. (Kenetron) from phase to ground and phase to phase. Sector cable to be re-used at 6.6 or 4 kv. is tested for three minutes at 40 k.v. d.c. (Kenetron) from phase to phase and ground. If round conductor, it is tested for one minute at 10 kv. a.c. from phase to phase and phase to ground. After installation, 6.6-kv. cable is tested at 24 kv. d.c. (Kenetron) or 10 kv. a.c. for one minute from phase to phase and from phase to ground. For 4-kv., cable is tested for three minutes at 16 kv. d.c. (Kenetron) or for one minute at 10 kv. a.c. in the same manner as 6.6-kv. cable.

A fifth company gives single-conductor 3-kv. cable an over-all visual inspection, and if passed, the cable then is tested for ten minutes at 10 kv. a.c. between conductor and sheath. Thirteen-kilovolt cables are given a visual examination and then subjected to the bending test, and if passed the cable then is tested for five minutes at 35 kv. a.c. between conductors and for five minutes between the three conductors and sheath at 22 kv. a.c.

A sixth company gives the cable a visual examination and then tests at 60 per cent of 2.5 times the cable rated (not operating) voltage.

A seventh company expects to test withdrawn cable for re-use at same test as for new cable.

P.C.E.A. Companies—One company reports that the salvaged cable is cleaned and inspected for pits and cuts in the sheath before it is put into service again, but makes no tests to determine the electrical strength of cable to be re-used.

Another company reports that if cable checks O.K. as to outward appearance, it is sent to the test department and given the following voltage test: three times rated voltage plus 2,000 from conductor to conductor for five minutes and 80 per cent of this voltage from conductor to ground.

A third company reports that the cable is inspected by the division engineer and underground foreman and, if it appears to be useable, the cable then is tested to twice the operating voltage for which it is intended to be used.

A fourth company reports that salvaged cable is thoroughly examined for sheath abrasions or any indications of physical damage before being reeled up, after which the cable is placed in stock for regular use. Electrical tests are made on cables to be re-installed only in the case of the 35-kv. cable. The physical condition of low-voltage (5 kv. or less) cable is considered to be a reliable indication of its suitability for re-installation.

A fifth company gives the cable sheath a visual inspection when withdrawn and an examination of the impregnation. If both are satisfactory the cable is sealed and returned to stock to be used at its original voltage. No electrical tests are made.

TABLE I—Some important measurements of duct-splices in high-tension and low-tension cable.

Type	Operating Voltage	Cable Diam. (in.)	Duct Splice Diam. (in.)	Inc. in Diam. (in.)	Length of Lap in Splice (in.)	Length of Splice (in.)	Test Voltage
3 x 350,000 circ. mil	11,000	$2^{9}/_{16}$	$2^{15}/_{16}$	$3/_{8}$	24	40	*19,800
	13,000						
2 x 1,000,000 circ. mil	300	$2\frac{1}{2}$	$2\frac{3}{4}$	$\frac{1}{4}$	$24\frac{1}{2}$	40	†5,500
							‡1,100
1 x 2,500,000 circ. mil	300	$2^{7}/_{16}$	$2^{15}/_{16}$	$1/_{2}$	20	48	†5,500
							‡1,100

*Conductor to other conductors and ground.
†Between conductors, and conductor to ground.
‡Between pressure wires and conductor, and to ground.

Salvaging of Short Pieces of Cable by "Duct Splicing"

As to splicing methods and data, the Metropolitan Section (New York) NE.L.A. gives the following information:

General Practice—The practice is to examine first the sheath, measure the length of the cable with a measuring machine on wheels and determine the condition of a sample of the insulation. If such cable passes satisfactorily, the length is tabulated and it is duct-spliced to such a length as will make it suitable for use again. That is, a long piece is spliced to a shorter piece to make a section of "average" length. Two long pieces may be spliced to make an emergency reel.

Present Method—When cable is duct-spliced it is subjected to the regulation factory test on the reel in the salvage shed, and if passed it is ready for installation. Such a cable can, of course, be spliced in advance and placed in stock to be used exactly as a new cable when required.

The salvage shed should be located conveniently with respect to the store yard so that cable can be moved into stock with a minimum loss of time and expense.

The completion of the record of salvage operations on any reel and the crediting of cable into stock can be arranged through one office.

Where a system has several operating voltages it might be desirable to use salvaged cable at a lower voltage than originally specified, but many systems have not this range for the same type of cable.

Splicing Data—Table I gives the more important measurements of duct splices on high-tension and low-tension feeder cable.

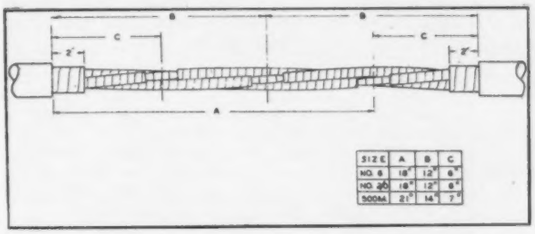
For single-conductor feeders of less than 2,500,000 circ.mil the joint usually is a butt joint and the increased diameter is covered by the thickness of the connector and the additional thickness of insulation. For the insulation, a higher type dielectric than that in the cable is used, such as varnished cambric saturated with varnish. For the high voltage joints a copper ribbon is wound around the splice from sheath to sheath and soldered to each to protect the insulation during lead-burning, to keep the ground potential close to the insulation, and to eliminate voids due to bending.

For transmission feeders made up of single-conductor cables, where several are to be installed in one duct, additional precaution must be taken by having the splices staggered.

Low-tension cable can be duct-spliced, but in most systems such cable can be used as the neutral leg and the splice can be made a short one with the conductor and sheath spliced together.

A large Middle Western company reports that it has made use of single- and multiple-conductor duct splices for the last ten years in conductor sizes ranging from 2/0 to 2,000,000 circ.mil and for voltages ranging from 500 to 20,000 volts. The operating record of these splices has been satisfactory and the practice of using duct splices is considered successful from an economic standpoint. In the 12-kv. duct splice varnished cambric tape is used for the insulation applied over the connector and exposed conductor insulation. The conductors are joined by interlacing strands and sweating over the connection a sheet copper connector. A lead sleeve slightly larger than the diameter of the applied insulation is slipped over the splices and wiped at both ends to the cable sheaths.

The duct splices are filled with minerallac No. 104-A which has a Saybolt viscosity of about 750 sec. at 100 deg. C. Careful filling is required because of the small volume of compound in each of these splices. The compound is allowed to cool and the voids are filled up by a second filling prior to the sealing of the sleeve. The over-all length of the 12-kv., 500,000-circ.mil, three-conductor duct splice is 18 in.



SIZE	A	B	C
NO. 8	18"	12"	6"
NO. 2/0	18"	12"	6"
500M	21"	14"	7"

Fig. 1. Three-conductor, 5-kv., duct splice partly assembled, showing staggering of conductor joints.

A P.C.E.A. company states that it does not splice short pieces of cable for use in duct lines, but that short pieces are carried in stock and fitted into jobs with as little waste as possible.

Another P.C.E.A. company reports as follows:

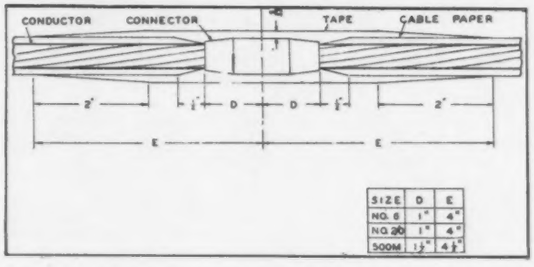
"Splicing short pieces of cable for use is done with success only up to voltage of 1.5 kv. for secondary service. An ordinary 15-in. lead sleeve is used and splices are made in only one of the two or three cables in a duct although there may be two or three splices in one cable depending upon the length of the span. This practice is applied mostly to residential areas where cable size rarely is larger than 2/0 as it is not believed to be good practice to splice cable in duct lines in downtown underground areas where cables are larger and carry heavy loads. No further tests are made on short pieces after splicing is done except to apply working voltage to line before taking load on cables.

A third P.C.E.A. company reports the following in connection with three experiments in duct-splicing:

"Three successful experiments have been made in connection with using up short lengths of cable and it is found, as in most experiments, that the best method is also the most expensive.

"**Experiment No. 1**—250,000-circ.mil, three-conductor, 11-kv. cable.

Ends stripped 5 ft. and conductors laid bare to within 8 in. of ends of armor on each end of splice. Each strand of conductor unlaid and laid in from other end of cable with some twist, ends butted and brazed. This has to be done very carefully and requires considerable time. However, when the operation is completed there are no stiff places in the conductor as is the case when a sleeve or solder without a sleeve is used. Each of the butted-and-brazed ends appear in a staggered location along the splice and the original lay or twist of the three conductors is maintained. Varnished cloth tape then is carefully applied to each conductor to very slightly more than the thickness of the original insulation. The splice then is slushed with hot compound and the fillers laid in after a bath in hot compound. The belt then is applied to its original thickness and a piece of split armor of same thickness as original armor and ¼ in. greater in inside diameter is applied. The seams at each end and along the split then are carefully burned together by an experienced and competent lead burner with regular lead-burning equipment. A splice thus made withstood a test of 30 kv. after being bent five successive times to a radius of 10 in. This practice is not recommended except where a large investment is represented in comparatively new cable in lengths of 100 ft. or more and where it would pay to equip a regular shop with the apparatus needed for such work. The average cost for such splices in sizes from 1/0 to 500,000 circ.mil is approximately $65 each, after equipment is purchased. Splices made by this method can be wound on a reel without injury to the splice.



SIZE	D	E
NO. 6	1"	4"
NO. 2/0	1"	4"
500M	1½"	4½"

Fig. 2. Detail of conductor joint and insulation for three-conductor, 5-kv. duct splice.

"**Experiment No. 2**—This is simply splicing short lengths of cable in the usual manner and winding them on a reel. This method is practicable with single- and two-conductor cable up to and including size No. 8. Sizes larger than this are apt to break when winding and unwinding on the reel. This method is not recommended.

"**Experiment No. 3**—This method has been in use in one district for more than 20 years, never has caused the slightest difficulty, and is restricted only by the size of duct into which the splice is to be drawn. No limit has been found to the voltage and number of splices

which can be pulled into a section of duct. Maximum voltage, however, for underground cable in this district is 11.5 kv.

"This method consists of hauling reasonably long lengths of cable (in sizes from No. 8 to 2,000,000 circ.-mil, for any voltage up to 11.5 kv. and for any number of conductors) to the job and making a standard splice which will enter the duct readily. The first length is drawn in leaving enough protruding from the end of the duct in the manhole to accommodate a splice. The end of the next length of cable then is brought into place and the splice is made and drawn into the duct with no bending or handling."

Typical Splicing Instructions

One P.C.E.A. company states, "We have made a study of duct splicing and are preparing to do some work along this line in the near future." The following is a copy of that company's Engineering Letter which covers instructions for making duct splices according to methods we contemplate using:

Instructions for joining short lengths of primary and secondary cables by means of duct splices, having a diameter small enough to permit their being drawn into the duct with the cable.

1. **Caution**—Since the duct splice has a much smaller diameter and considerably less insulation than the usual type of splice, both the material and workmanship must be the best obtainable. It is absolutely essential that every possible precaution be taken to keep all dirt and moisture out of the splice.

All of the splices described herein are to be insulated with special high-voltage paper tape, such as is furnished for use in the 33-kv. cable joints.

2. **Cutting and Connecting 3/C Primary Cables**—Connectors on the three conductors are to be staggered as shown in Fig. 1, which shows the cutting dimensions for the three-conductor splice. Figure 2 shows the details of the connection in each conductor.

Remove the lead sheath from the end of each cable to dimension A. Bind the belt insulation near the end of the sheath with saturated flax twine to prevent loosening and remove the belt insulation to within 2 in. of the end of the sheath. Cut the fillers off near the belt insulation, being very careful not to cut into the conductor insulation.

Cut off two of the conductors of each cable to dimensions B and C, respectively. Tie the insulation near the end of each conductor to prevent loosening and remove the paper to dimension D. Place the cable ends together in such a way that the original spiral lay of the conductors will be maintained and sweat on the connectors.

3. **Applying Insulation—3/C Primary Cables**—Remove all soldered drops and points from the connector and pencil the conductor insulation back ½ in. from the connector. Be careful not to loosen the ends of the paper tapes, and to leave a smooth penciled surface. Fill the irregular space at each end of the connector with saturated flax twine. Apply the special ¾-in. paper tape, with a one-half lap, to the dimensions shown in Fig. 2. The surface on which the tape is being wrapped is to be kept covered at all times with a wrapping compound consisting of 50 per cent petrolatum and 50 per cent transil oil.

Where the taping over the three connectors has been completed lay the conductors together as smoothly as possible and fill the spaces between them with jute filler saturated with the wrapping compound. This material must be tightly packed so as completely to fill the spaces and leave a smooth, firm surface for the application of the belt insulation. Then apply a half-lap wrapping of the 1-in. paper tape from lead to lead, to a thickness of 5/32 in. with a 2-in. tapered section at each end.

4. **Applying Lead Sleeve**—Turn up about ¾ in. of the lead sheath at each end of the splice, forming a flat bell. Wrap the entire exposed insulation surface with No. 40 B&S gage copper ribbon, 1 in. wide, using a one-half lap. The sleeve is to be made from a piece of lead tubing having a ⅛-in. wall, split open lengthwise and trimmed to leave an open gap of ⅜ in. at each end and a narrow slot lengthwise of the cable after the sleeve is tightly fitted over the splice. Hold the sleeve in place with double turns of soft iron wire at about 5-in. intervals. Tighten these bands by twisting the ends as the sleeve is carefully tooled to the cable. Spot-weld the slot between each pair of band wires by means of a lead burner's flame and remove the wires. Then fill the slot with pure lead, giving two complete treatments with the lead burner's flame, later scraping off all surplus lead. Tool the belled ends of the cable sheath down to lap over the ends of the sleeve and complete the joint with the lead burner's flame. The splice may be thrown onto the other side of the make-up reel to complete the under side of the lead joints at the ends of the splice. The lead strips used with the lead burning process must be pure and must be scraped by hand just before using to insure elimination of scale and oxidation. Cable sheath lead must **not** be used.

5. **Testing 3/C Primary Cables**—Each completed reel of cable containing duct splices shall be given a high-voltage test at 17 kv. between conductors and between conductors and sheath. The test shall be made with 50- or 60-cycle alternating current for a duration of five consecutive minutes on each connection.

Equipment for Duct Splicing

From the Metropolitan Section, New York, N.E.L.A., the following data on equipment are presented:

"The amount of cable to be salvaged in a big company calls for labor-saving devices to speed operations and reduce costs. An up-to-date salvage room will include overhead cranes for handling cable on the floor and moving spliced cable to and from the test room, motor-driven reeling devices necessary to examine the cable when being transferred from one reel to another, a measuring machine to check the length before and after splicing (to involve no additional expense as the cable passes through it in the operation), proper equipment for duct splicing and lead burning and equipment to burn the under side of the splice, and a cable straightener for small cables which may be kinked or bent short in handling, used just as the salvaged cable is wound on a reel.

"The test room is an important feature and should have a safety device to assure that no one can enter while high voltage is being applied."

Economies of Cable Salvage

In the question of economies involved a variance of opinion and results is found. Obviously if the duct splicing, except in the case of cable shortage, does not result in a saving it is not worth while to carry it on.

A large Eastern company reports the following amount of work passed through its salvage shed:

Testing and re-reeling 1,300,000 ft. of cable, 4,900 reels.
Duct-splicing 165,000 ft. of cable, 690 duct splices.
Neutral handling and splicing 790,000 ft. of cable, 13,400 splices.

A study made of the cable salvage situation for the year 1926 indicated that a net saving of approximately $750,000 was realized by the company in question.

Another large Eastern company states as follows:

"We do not splice together short pieces of cable, as studies which we have made indicate that there is not a sufficient amount of this cable of sizable lengths collected to warrant establishment of a force that would make such work worth while."

The Metropolitan Section, New York, N.E.L.A., gives the following data on cost:

"The principle is to make the least number of splices to produce a cable of proper length and, although economically it may be desirable to use a 25-ft. piece of

cable, it would not be necessary to splice together ten such pieces to make a 250-ft. length.

"Knowing the cost of the particular splice and the new and junk value of the cable, it is easy to figure the economically correct length of cable to salvage for each type.

"Each splice must be studied individually. For multiple-conductor high- and low-tension cable the ends must be lapped so as to make a splice which will be long enough and small enough to conform to the specifications. The insulation and impregnation must, when completed, be equal to that of any part of the cable, must stand the factory electrical tests, and the sheath must be flexible.

"Only lead-burning the sheath over the splice will give the necessary flexibility and conform to the diameter limitations."

Conclusion

The foregoing gives a summary of the re-use of withdrawn cable and of the subject of duct-splicing of short pieces of cable. It is hoped that the information presented will aid member companies in the study of this question.

Further information on the subject of duct-splicing and the salvaging of used cable may be found in an article by C. H. Shaw in the October, 1926, issue of "Electric Light and Power."

Foremen Training and Conference

By W. L. SMITH*

The foremen conference and training plan is worked out on the assumption that the foremen already possess most of the knowledge necessary to perform their work well, but require the ability to analyze this information and to organize it into such shape that it will help them to co-operate more completely with their fellow foremen and also to assist them in obtaining better team work from their men. On this basis the conference proceeds in terms of objectives to be obtained, the foremen group developing their own subject matter through discussion of leading questions. The primary object is to develop the foremen's thinking and a more elastic state of mind by guiding them in working out specific problems instead of introducing general information. A sample case is presented to show the order and value of the conference procedure. Practical application of the foremen conference method in a public utility is cited and a plea is made for a more general use of this method to promote increased efficiency of the foremen.

PUBLIC utility managements and industry as a whole generally have selected practical men to serve as foremen, men who have grown up in the industry and who have won a place for themselves as foremen as a result of their possessing certain qualities of leadership and a thorough knowledge of their work. Relatively speaking, very little attention has been paid to the foreman in the past by the utility managements in the matter of developing the minds and attitude of the entire group of foremen to a point where there is true co-operation between the foremen. True co-operation is considered to be the kind which the foreman gives because of his interest in the work of the organization as a whole and where he does a little more than the responsibilities of the job require. Not a great deal, either, has been done to help the foremen analyze the knowledge that they have into such shape that it will assist them to get better team work from the men under their supervision.

Those who are attempting to improve the economics of the industry would do well to investigate and study any method that would help to improve this phase of industrial life. Therefore, it may not be amiss to emphasize the best recognized plan of education and training which has been designed to help foremen bring themselves up to a point where their abilities are utilized to the highest degree.

Educational Conferences

The type of educational procedure which has been most successfully used, although not generally understood or appreciated by most public utility managements, is that of the so-called "conference method" as developed by the Federal Board for Vocational Education under the leadership of its editor and educational consultant, Charles R. Allen, and also the chief of trade and industrial education, Frank Cushman. (It has been the writer's good fortune to receive complete instructions regarding this method of educational procedure given by Mr. Cushman to a group of foremen conference leaders, and to use it in putting over ideas and programs in connection with accident prevention work, particularly that of dealing with members of various safety committees, and also with foremen groups in connection with fixing responsibilities when certain cases of major accident investigations have been carried on.)

The plan of the conference method provides for a qualified leader who may be an outsider, but preferably an executive of the industry who does not have direct supervisory authority over the particular group of foremen in question. A safety supervisor or safety engineer has a good opportunity to develop in this direction. He must be a leader of discussion rather than the informational or instructional type of teacher. His work is not that of thinking the foreman's problems out for him and then telling the foreman what to do, but is rather the stimulating of the foreman to do his own thinking so that he will develop the ability to use his own head in carrying out his work.

Adequate quarters to hold meetings, containing necessary chairs, tables, blackboards and charts are, of course, essential provisions in carrying out the work of foremen's conferences. A leader skilled in the work of training foremen through the conference method will use his blackboard and chart facilities to good advantage in setting up the appraisal of the various analyses of problems that will be made. The information secured from the conference can be so arranged that the relationships of all material used will properly be emphasized visually before the group.

Meetings should be held preferably on the company's time; the frequency can be varied according to circumstances.

The general outline or stages of the conference method of procedure have best been characterized by Mr. Cushman as follows:

1. Assembly of data or facts concerning a problem or question.
   (a) From first-hand experiences. (Personal experiences.)
   (b) From second-hand experiences. (Experiences of others.)
2. Selection of data or facts which are pertinent to the problem or question under discussion.
3. Placing of proper importance on the above data or facts.
4. Making of some sort of decision or arriving at a conclusion.
5. Making of a plan to carry out the decision.
6. Carrying out of the plan would necessarily extend over an indefinite period after the particular conference has been finished.

The conference leader, in carrying the conference meeting through the foregoing five stages must have at his command the devices listed in the following tabu-

* Report prepared for presentation at joint meeting of underground systems committee and accident prevention committee.

lation and must know at what stage of the conference the ralative utility of such devices is to be brought into action. These more or less overlapping devices also are characterized by Mr. Cushman as follows:

1. Cases by the leader.
2. Cases by the group members.
3. Direct statements by leader.
4. Direct discussions by leader.
5. Direct statements by group members.
6. Discussion.
7. Analysis—various types.
8. Built-up list of functioning data.
9. Illustrations by leader.
10. Pro and con analysis.
11. Evaluation of data by leader.
12. Graph.
13. Suggestions from group.
14. Majority opinion.
15. Summary or report.
16. Direct questions.
17. Overhead questions.
18. Points for discussion.

A sample case of conference might be given here to illustrate the procedure.

Sample of Typical Conference

The following information is presented by a leader for an hypothetical case before a group of say fifteen representative foremen selected from the overhead construction department of a public utility.

A line construction foreman for a power and light company was given orders (a hurry-up job) to install a primary circuit on poles carrying an energized distribution high line. A certain portion of this high line was routed over a canyon and one pole was located at the bottom of this canyon. After the new crossarms had been installed the standard clearance distance below the energized line and new wires had been strung on the crossarm, the foreman then either instructed or permitted the men on the service truck to take up the wires by attaching the wire direct to the winch on the truck. A lineman was stationed on each pole to tie down the new wires when the proper tension was secured. The lineman at the point in the canyon failed to secure one of the wires properly to the crossarm and when a full tension was placed upon the wire it flew into the air, coming into contact with the energized high line circuit above.

Two men working at the service truck were injured and a third man feeding the wire over the winch was instantly killed. It was shown afterwards that it was contrary to good practice to attach a wire under such circumstances directly to a winch. A rope should have been used with a tackle between the wire and the winch. The line being installed should have been properly grounded and, furthermore, there was no reason why the distribution high line could not have been taken out of service as the points fed on that line could have been supplied temporarily from another circuit. The foreman took none of these precautions.

The accompanying tabulation shows a form of discussion outline that may be used in the conference, developed on the blackboard.

It will be brought out in the conference, as an important point, that this is a good example of taking unnecessary chances in order to do a hurry-up job. It was expensive both in life and property and actually slowed down the accomplishment of the work.

Such a case brings out much constructive discussion from the foremen and serves to bring out many other points which will emphasize to the foremen their responsibility for efficient supervision, including safe methods of doing work.

The foregoing example of the conference procedure is illustrative of how the method may be used in selling accident prevention and safety to a group of foremen. The conclusions arrived at as a result of thinking through the problem help the foremen to identify their own responsibilities as supervisors or instructors to the men in their department. The objective in the mind of the leader in this particular conference might be to secure secretly a recognition of the responsibilities on the part of the foremen. Having obtained that, it would be comparatively easy to establish a policy of holding each individual foreman responsible for knowing that each of his men possesses at least the minimum knowledge and skill necessary to do the work to which he is assigned and also to see to it himself that all safe methods of doing work are employed.

An Accident Tabulated for Discussion

Possible Causes	Losses	Foreman's Responsibility	How to Prevent
Carelessness.	One man's life.	Proper placing of men.	"Kill" the high line before starting on the job.
Poor planning.	Two men seriously injured.	Anticipating hazards on job.	Proper grounding of wires men were installing.
Thoughtlessness.	Material.	To use safe methods of doing work.	Use approved methods of tying in line (at the point where line got loose).
Poor working conditions.	Time.	To give specific instructions to a man. In this case the one on the pole in the bottom of the ravine.	Use a rope on the winch-end instead of pulling directly on wire.
Too much of a hurry.	Repairs.		
Taking unnecessary chances.	Compensation.		
Poor supervision.	Hospital expenses.		
	Slowing down an entire job.		
	Loss of a citizen.		

Mr. Cushman has pointed out aptly several other important objectives that might be obtained by the conference methods in dealing with groups of men of experience who carry supervisory, administrative or instructional responsibilities. These objectives are as follows:

1. Modifying the viewpoint of some or all the group members for the purpose of securing better team work in the organization.
2. Helping each group member to analyze his job, identify his responsibilities and discover better and more effective ways of meeting his responsibilities.
3. Assisting each individual member of a group to organize his experiences to the end that they may be of increased value to him on his job.
4. Making analysis of situations or cases involving joint responsibilities in order to secure a smoother working organization.

It has been called to the writer's attention that a program of foremen's training using the conference method has been started very recently in the Consolidated Gas, Electric Light & Power Company of Baltimore, Maryland, with the assistance of the Maryland State Board for Vocational Education and Frank Cushman of the Federal Board for Vocational Education. This program affects some four hundred foremen of that particular company and it also is significant to note that the educational director and "foremen's cabinet" of that company adopted the conference method of training in preference to all other types of educational procedure.

Since the foreman is charged to a large degree with the responsibility of constructing, operating and maintaining public utility systems, it naturally follows that anything that can be done to promote the increase of efficiency of his supervision in matters relating to his responsibilities is a clean-cut business proposition.

Protecting High-Voltage Cables During Construction

By C. H. JENKINS*

THIS subject involves a matter which apparently is being handled by all member companies in much the same manner. It appears to be accepted common practice to construct and/or rebuild manholes through which pass live high-tension cables operating at voltages of 15 kv. and under.

The usual practice when intercepting a conduit line is to remove carefully the ducts from the cables, after which they are covered with burlap or blankets for protection from mechanical damage to the cable and injury to the workmen. The cables then are supported by ropes or wires attached to timbers or rails spanning the manhole at the pavement surface. Cables thus are independent of the manhole structure so that the construction may be done with reasonable facility and minimum risk provided special care is exercised by the workmen.

Apparently very little manhole construction work has been done where cables in excess of 15 kv. are involved. It would appear, however, that greater precaution should be taken when such cables are present and "alive," because of their high replacement cost and the hazard in event of their failure.

* Report prepared for the underground systems committee, Engineering Section.

Current Regulating Transformer Installation

By P. E. CHAPMAN and G. H. BRAND*

IN recent years the demand for more street lighting electroliers and for electroliers having lamps of greater candlepower has made the installation of underground street lighting equipment of considerable moment. In an effort to familiarize members of the underground systems committee with methods employed by the various companies to meet this problem, questionnaires were sent to the various members and from the various answers received this report was prepared.

Provision of vault space for current regulating transformers is influenced by the method of supplying and controlling them. In this report it was decided to describe briefly these methods and their relation to the provision of vault space.

The method most generally used has been the installation of current regulating transformers either in distribution manholes and vaults or in special vaults and manholes built to take care of this equipment. These transformers are supplied either from a street lighting feeder or from a commercial feeder. If they are supplied from a commercial feeder they are energized at the proper time by the use of a time switch or a control circuit.

Answers submitted by the various companies showed that out of the seven companies installing current regulating transformers two companies build special vaults; two other companies as a rule build special vaults, but frequently make use of distribution transformer vaults; and three companies use distribution manholes or transformer vaults exclusively for the installation of these transformers.

* Report prepared for the underground systems committee, Engineering Section.

This variation in practice is greatly influenced no doubt by local conditions which are the determining factor in most cases, but a number of reasons have been advanced for making installations of current regulating transformers either in vaults specially built or in distribution manholes. One company does not believe the installation of these transformers in distribution manholes to be practical because of the heat emitted by them. It is quite true that the ventilation of these transformers has been a problem. It has been the practice of some companies when several transformers have been installed in the same hole to install a ¼-hp. blower to drive warm air out of the hole. When only one or two transformers are installed, only natural ventilation by means of ventilating shafts is used.

Distribution vaults often are crowded with distribution equipment and the installation of street lighting equipment would require the rebuilding of the vault. In these cases it frequently is more economical to build a new vault or manhole for the street lighting equipment. Some companies have laid out the street lighting circuits so that a number of them may be fed from one location. This means the installation of a large number of transformers, which if installed in a distribution vault or manhole would not leave any room for distribution equipment. In these cases the logical procedure has been to build a separate transformer vault for the street lighting installation.

If street lighting equipment can be placed in the distribution manholes or vaults the cost of installation of course is reduced considerably. When this is done, a more flexible system is established because in emergencies distribution feeders may be tapped to energize the street lighting transformers. Where street lighting equipment is fitted in with distribution and maintain. On some streets it is difficult to build additional vaults at desired points because all of the available space is occupied by various utilities. In these cases if required space is available in distribution vaults it may be desirable to install the equipment in them.

In summing up the various arguments advanced either for or against the installation of street lighting equipment in distribution manholes it appears that installation in distribution vaults gives a more flexible and unified system, fewer points to inspect and maintain, and a more economical system is established.

Major arguments against installation in transformer vaults appear to be:

(1) The large amount of street lighting equipment crowds the distribution equipment.

(2) Excessive heat given off by street lighting transformers necessitates forced ventilation and reduces the efficiency of the distribution equipment.

(3) Distribution vaults may not be large enough to take care of street lighting equipment and future commercial growth, in which cases it is more economical to build a special vault.

The building of street lighting vaults in the downtown area or in underground districts in most cases is done by the electric company. In suburban districts the power company may build the vault and charge the tract owner, or the tract owner may build the vault according to the power company's specifications. The power company installs the street lighting equipment, or part of it, at the tract owner's expense.

Opinions expressed by practically all of the companies is that the installation of current regulating transformers for street lighting inside of buildings is very undesirable. These transformers give out considerable heat, they must be inspected frequently and the noise and vibration from them may be excessive. A location in the street where the ventilation can properly be taken care of, where the vibration will not bother anyone and where they are easily accessible appears to be highly desirable.

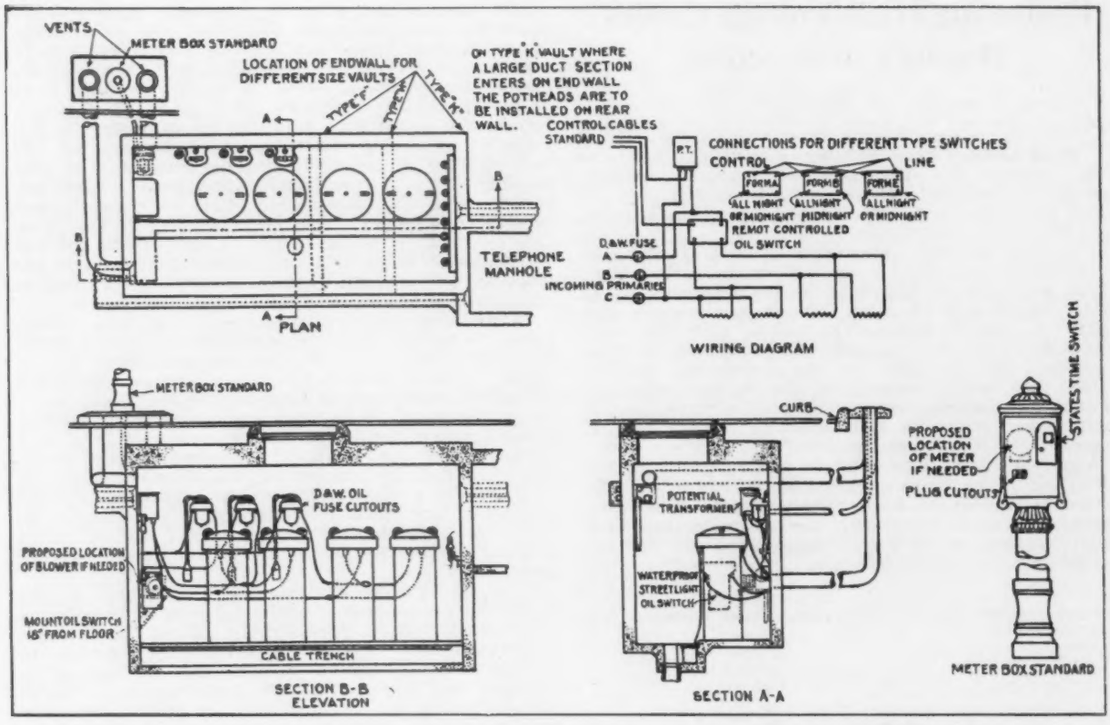


Fig. 1. General plan of current regulating transformer installation in special street lighting vault as installed by the Los Angeles Bureau of Power and Light.

Size of Current Regulating Transformers

The size of constant-current transformers used appears to vary with the individual company. Several companies use sizes varying from 3 to 30 kw. while other companies standardize on one or two of the larger sizes. One company uses nothing but 30-kw. units, another company uses nothing but 20-kw. and 30-kw. units, while another uses nothing but 15-kw. units. Where the light density is great and where a large number of lamps per block is installed, it is more economical to install the larger sizes.

There are numerous arguments for the installation of the larger sizes of constant-current transformers, especially where a large number of lamps must be fed in a comparatively small area. A 20-kw. transformer loaded to capacity (assuming a unity power factor load) will handle only 80 400-cp. lamps or only 56 lamps of 600 cp. Where lamp standards having two 1500-cp. lamps are installed, only 12 standards can be fed from one transformer. With the 20-kw. and 30-kw. transformer installation a higher voltage cable is necessary, but this additional cost is more than offset by the fewer transformer installations required.

Standardizing on the larger sizes of these transformers keeps the stock of transformers on hand at a minimum. It also cuts down the first cost and the cost of maintenance because there are fewer points to control and inspect with the larger transformers. Because of these reasons the standardization on one or two sizes of transformers appears to be desirable.

Method of Supply and Control

There are various methods of supplying and controlling these transformers as reported by the companies. The method in general favor appears to be that of a street lighting primary feeder run from the substation and feeding a number of current-regulating transformers. These feeders are thrown in either by hand or by remote operation at the substation. In using this method the street lighting system has been isolated from the distribution system as much as possible and a local outage is not apt to affect street lights. Whereas, if the transformers receive their energy from a local distribution feeder an outage would put both domestic and street lights out and would create a hazard as well as make an unfavorable impression upon the public.

In outlying vault installations one company uses a remotely controlled oil switch located in the vault and controlled by a time switch located in a curb pedestal (See Fig. 1). The 110-volt a.c. control circuit is fed from distribution secondaries where available, otherwise by a special subway potential transformer. Another company uses a control switch which connects the street lighting transformer to the distribution transformer and which is thrown in by means of a time switch or by another series arc circuit.

It appears to be the concensus of opinion that where the load density is great, as in the downtown area, the street-lighting-feeder method of supply and control is to be desired. In outlying tracts where the cost of this method would be prohibitive various other methods appear to be profitably employed.

Types of Transformers

Whether to install overhead or underground type of current-regulating transformer appears to be a question that is decided principally by local conditions and the type of transformer used for distribution purposes. The companies using overhead transformers for distribution use overhead transformers for street lighting and vice versa. One company, where some water was encountered, took an overhead transformer.

removed the leads, installed nipples on the case, wiped the lead-covered cable to them and had a fairly good subway transformer except as to heat dissipation. Where any large amount of water is encountered or where there is danger of submersion, underground transformers are used.

Cable and Cutouts Used With Transformers

Cable used to connect these transformers with the circuit varies with the transformers used and with the company. The primary side of the transformer is connected by means of simplex cable varying from

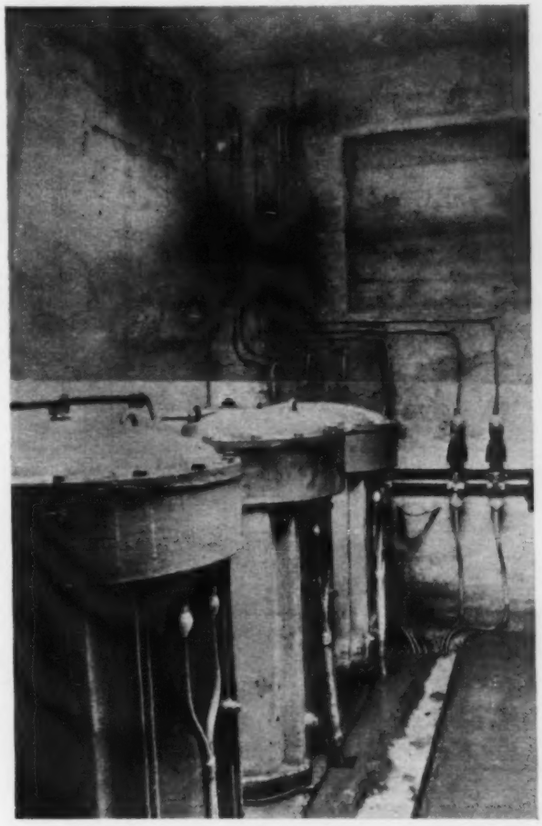


Fig. 2. Current regulating transformers installed in a street lighting vault by the Los Angeles Bureau of Power and Light.

No. 4 to No. 8 in size and from 5,000 volts to 2,400 volts in insulation. The secondary is connected to the circuit by means of small simplex cables varying in size and insulation.

Cutouts used on these current-regulating transformers are 50-amp. oil-fuse cutouts on 20-kw. transformers and smaller; above 20 kw. 100-amp. cutouts are used. Most of the companies use this cutout both as a fuse and as an oil switch. These cutouts have given good service except where too small a cutout was used on a 30-kw. transformer and would not serve successfully as an oil switch.

Vibration and Noise of Transformers

Several companies have had complaints because of the noise and vibration of current-regulating transformers. In order to stop this noise one company installed a length of piano wire in the vault and tuned it until the vibration had stopped. In another case a cushion made of old automobile tires was placed under the transformer to take up the vibration. In this particular case the transformer vault was built against

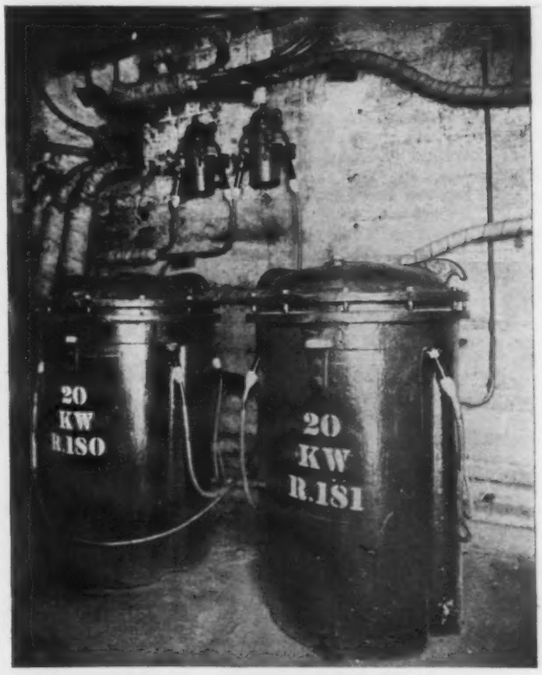


Fig. 3. Two current regulating transformers in a distribution manhole in San Francisco.

Fig. 4. An installation of a 20-kw. current regulating transformer with two street lighting transformers in a distribution manhole in San Francisco to reduce voltage on cables. The current regulating transformer is supplied from a primary street lighting transformer.

the bulkhead of a building and vibration was transmitted directly to the building.

Another company reports the complaint received from an installation of three 10-kw. current-regulating transformers located in a vault about 50 ft. from the house from which the complaint originated. At certain places in the house the vibration was quite noticeable. An attempt was made to prevent the

vibration of the transformers from being transmitted to walls and floor of the vault, by placing cork pads under the transformers. This reduced the vibration in the vault but did not materially lessen the vibration in the house. Further investigation seemed to indicate that the vibration was transmitted to the house through water pipes. It was believed that the water pipe came into contact with a pipe containing street lighting cables. It was impossible to verify this as the owner of the house objected to having the parkway torn up.

A report was received of a company receiving a complaint due to a 20-kw. transformer in a distribution manhole situated near the end of a blind street. The street on two sides was lined with tall apartment houses and ended against a retaining wall which arose about 20 ft. above the surface of the street. Due to this sounding-board effect of the surrounding walls any noise in the street was greatly magnified. The transformer finally was removed to a nearby manhole.

Standardization of Reels for Lead-Covered Cable

By G. H. HAGAR*

Notes on standardization giving tabulated results of a questionnaire and a formula for calcuating reel size.

THE QUESTION of standardization of sizes and dimensions of reels for handling lead-covered cable has been advanced due to the wide and growing use of such cable.

Table I gives information based upon answers to a questionnaire which was sent out to the cable using companies in California.

Of the six companies answering, three stated that they left the matter entirely to the manufacturer and gave no figures. Two companies gave figures showing their ideas as to dimensions, one qualifying the figures by stating that it left the matter to the manufacturer. One company stated that it had accepted the proposed standards drafted by a joint subcommittee of the N.E.L.A. and the Insulated Power Cable Engineers Association. None of the companies advocates any special design features and none of them appears to be using iron reels of any description for handling lead covered cables.

Only two companies have had any trouble with the reels that they have been receiving in the past. One of these companies advocated standardization more upon the basis of the well-known benefits of standardization generally. The other four companies had experienced practically no trouble and looked upon the reel as a vehicle which the manufacturer must furnish to transport the cable.

Therefore, it is concluded that there is no general call in California for standardization of reels for handling lead-covered cables. It appears also that the question has been studied in the East and that dimensions of reels and maximum lengths of cable to be shipped on one reel are being agreed upon.

Proposed National Reel Standardization

Proposed standard sizes of lead cable shipping reels as approved by the Insulated Power Cable Engineers Association, December 6, 1927, are shown in Table II.

These reels are intended for paper-insulted lead-covered power cable, varnished-cambric insulated lead-covered or braid-covered power cable and rubber-insulated lead-covered power cable. The list was built primarily to meet the requirements for paper-insulated cable since that product requires the most care in shipping.

Armored cables, triplex cables above 35-kv. rating, single-conductor cables of 66-kv. rating and more, and special cables are not definitely provided for in this list although in some cases these reels may be suitable for such purposes.

Although the N.E.L.A. paper-insulated lead-covered cable specifications permit a ratio of 14/1 in drum diameter to cable diameter, these reels are designed on a 16/1 ratio to give a greater safety factor. This does not necessarily mean that in all cases a 16/1 ratio will be strictly observed, for the 14/1 ratio is permissible and certain cable makers under special conditions will desire to avail themselves of the lesser ratio.

To make reels strong and durable and yet of sufficient traverse so as not to tip over, a 2/1 ratio for flange diameter to inside traverse was adopted after considerable study. The footages for various cable diameters must be considered approximate. Opinions differ as to possible footages on reels and accuracy in laying cable on reels will vary somewhat. Also clearance under lags may be varied to suit individual requirements and opinions.

In normal manufacture multiple manhole lengths pass through the lead presses. Hence where testing capacity and other conditions will permit it is desirable to ship more than a single manhole length per reel, particularly in cables under 20-kv. rating. Shipping

TABLE I—Cable-reel questionnaire data from California companies.

EU 11-I	Company						
	A	B		C	D	E	F	
Cable Diameters	.....	2 in. or less	Over 2 in.	.....	.....	.....	2 in. or less	Over 2 in.
Dimensions of reels	Left to Mfgr.	.....	.....	.....	Left to Mfgr.	Have accepted proposed standards of Committee of NELA & I.P.C. Eng. Assn.	.....	.....
Width—Max.	Left to Mfgr.	48	60	.....	.....	.....	36	60
Min.	Left to Mfgr.	36	48	.....	.....	.....	.....	.....
Flange Diam. Max.	Left to Mfgr.	60	72	Left to Mfgr.	.....	.....	60	72
Min.	Left to Mfgr.	36	48	Left to Mfgr.	.....	.....	.....	.....
Drum Diam. Max.	Left to Mfgr.	30	48	.....	.....	.....	.....	.....
Min.	Left to Mfgr.	20	36	.....	.....	.....	24	36
Shaft Opening Max.	Left to Mfgr.	2½	3½	.....	.....	.....	3	3
Min.	Left to Mfgr.	2	3	.....	.....	.....	2¼	2½
Max. Weight (lb.)	Left to Mfgr.	6000	8000	.....	.....	.....	.....	8000
Special details of construction	None	None		None	None	None	None	
Use iron reels	No	No		.....	No	No	No	
Troubles with present reels	Pract. None	None		.....	Pract. None	Have had to make up special shafts. Have received reels too large for trailers.	Have had to modify equipment to handle different sizes.	
Need for standardization	None	None		None	None	Yes, on basis of benefits of standardization generally.	Maximum outside dimensions, weight and shaft opening should be standardized.	

* Report prepared for the underground systems committee, Engineering Section.

TABLE II—Lead Cable Shipping Reels—Proposed standard sizes and total feet of cable per reel—prepared by the Insulated Power Cable Engineers Association, Dec. 6, 1927.

	A	B	C	D	E	F	G
Flange Diam. (in.)	36..	48..	60..	66..	72..	78..	84
Inside Traverse (in.)	18..	24..	32..	36..	36..	36..	48
Outside Traverse (in.) (Approx.)	25..	31..	39..	43..	43..	43..	55
Drum Diameter (in.)	16..	24..	32..	40..	48..	48..	56
Clearance under Lags (in.)	1..	2..	3..	3..	3..	3..	4
Cable O. D. (in.)	$F = *\frac{(A-X+B)}{12}$		$\frac{(A-X-B)}{2}$		$\frac{C}{2d}$	$\frac{}{d}$ (Less 4%)	
0.25							
0.30							
0.35							
0.40							
0.45							
0.50	4,060						
0.55							
0.60	2,820						
0.65							
0.70	1,880						
0.75							
0.80	1,515						
0.85							
0.90	1,252						
0.95							
1.00	1,020	2,050					
1.10		1,615					
1.20		1,368					
1.30		1,078					
1.40		1,018	1,665				
1.50		820	1,590				
1.60			1,300				
1.70			1,170				
1.80			1,100				
1.90			865	1,130			
2.00			865	1,130	1,033		
2.10				855	976		
2.20	**	**		805	920		
2.30				753	647		
2.40				753	647	1,130	
2.50				704	603	846	
2.60					560	753	
2.70					560	783	
2.80					517	725	
2.90					517	725	796
3.00					517	725	796
3.10							748
3.20							748
3.30							697
3.40							465
3.50							432

d = diameter of cable
F = feet
C = inside traverse
A = flange diameter
X = 2 x clearance
B = drum diameter
** whole numbers, i.e., drop fractions of turns

two manhole lengths per reel saves the utility not only in reduced factory cost, but also in trucking to the street location, in protection of reels on the street and in reduced freight expense for the return of fewer reels. The Cable Engineers Association urges this as universal practice since the reel standards have been drawn up on that basis.

If these standards meet with the approval of the utilities no wholesale scrapping of present shipping reels is contemplated, but the process of change-over will be gradual over a period of probably three or more years, according to the Cable Engineers Association.

Automatic vs. Manual Transfer of Load

By H. H. BUELL*

A discussion of the engineering features of load transfer including a comparison of conditions in Eastern and Western territories with the suggestion that greater effort should be made to make present equipment more reliable rather than furnishing duplicate service under Western conditions.

A comparison of operating conditions with manually operated and automatic transfers and a discussion of western requirements in transfer equipment and a detailed description of an automatic transfer installation.

AUTOMATIC versus manual transfer of load between circuits in underground distribution is a subject which is of such wide application and includes so many possible combinations of conditions that it has been found desirable merely to outline the principle involved and to describe the methods which have been employed in a relatively few instances by many different companies to cover the situations as they existed. It was found to be impossible to secure through a questionnaire any rules which may be made to apply in all cases and therefore each case must be considered individually. The companies on the Pacific Coast gradually are reaching the point where more and more use is being made of transfer switches for this purpose.

Although the subject may appear to be entirely definite it is very difficult to keep the report entirely within that definite meaning. As a matter of fact it is desirable to deviate from the subject and to introduce information gleaned from reports published elsewhere as well as from answers to questionnaires. This subject, like most others considered by engineers, must be approached from two angles, service and cost, and the two must be weighed one against the other in arriving at a solution. This probably is more true in connection with underground construction than with overhead construction because of the inherently greater cost of the former. It is apparent however that the transfer of load between circuits is of equal interest in both cases since the need, if it exists, is as great in the one case as in the other, where both supply the same class of service. Answers to the questionnaire sub-

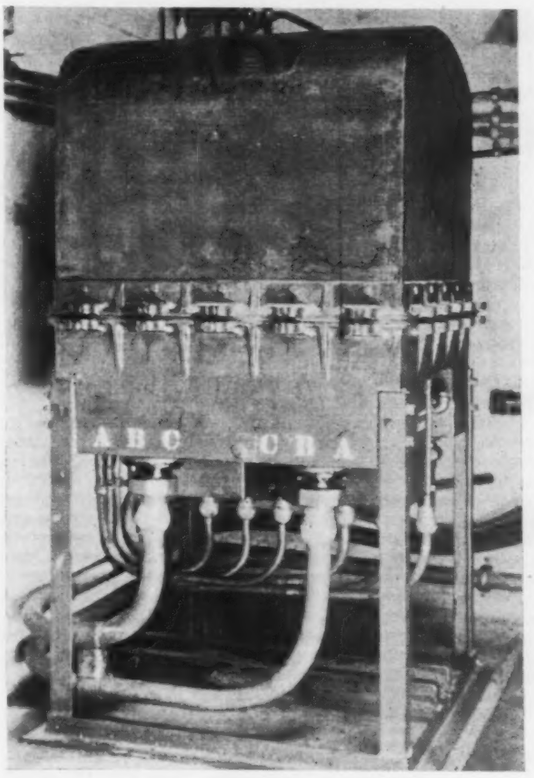


Fig. 1. An automatic transfer switch.

* Report prepared for the underground systems committee, Engineering Section.

mitted by this subcommittee have been complete and helpful in the preparation of this report.

The transfer of load between circuits has been taken to refer, as far as this report is concerned, only to those cases where duplicate service is furnished to a consumer or group of consumers. Naturally the only

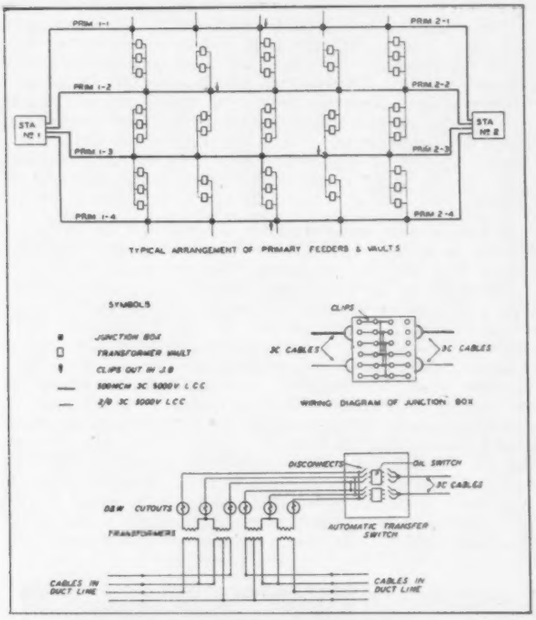


Fig. 2. Wiring diagram of transformer vault (below) and typical arrangement of feeder and vaults (above).

possible need for duplicate service to any class of load is because of a lack of reliability of the normal feed for that load. In the large Eastern load centers there is no question but that in large areas a duplicate source of power is economically reasonable and justifiable. This may be considered as due to the fact that the sources of supply in most cases consist of large steam stations closely grouped with relatively short feeder circuits and these for the most part underground. It is agreed that the economics of the situation are entirely changed in California, for instance, where load centers are supplied through long transmission lines intricately connected together and fed from many individual hydro and steam stations widely separated.

In the former cases such disturbances as may occur are for the most part due to feeder trouble or to transformer trouble in the substation or at the load, whereas in the latter cases disturbances are due both to these causes and also to system troubles which may be said to be proportional to the extent of the system and may be of considerably greater number. These system disturbances or failures naturally cannot be corrected by either automatic or manual transfer equipment. It is, of course, appreciated by all who have studied the matter that automatic throw-over equipment is considerably more costly than is manual equipment of the same capacity and it is a debatable question therefore whether the additional cost of the former is justified even where duplicate service seems to be indicated, as the companies are operating in California.

Cable and transformer failures are very rare in most properly maintained underground systems. This is not entirely true of overhead systems supplying the same class of service because of the exposure of such lines to various damaging influences such as trees, fires, and automobiles and trucks. Many of these trouble sources are beyond the control of the operating engineer. Where these two types of system are tied together and operate as one the greatest number of circuit disturbances is possible. In our rapidly growing communities changes in cable systems and connection or disconnection of load require frequent shut-downs on feeders since few operating companies consider it safe to work on energized cables in underground systems.

All of these reasons as well as others have been responsible for some companies furnishing duplicate service to certain classes of consumers, particularly those which would suffer a great monetary loss or possible loss of life in case of a serious service interruption and where such an interruption can be prevented or reduced to a minimum by the installation of throw-over equipment. The type of load served in this manner includes hospitals, theatres, large hotels, clinics, subterranean thoroughfares, or public buildings where duplicate service is required by law and where it can be furnished

Transfer of load between circuits is accomplished in almost as many ways as there are devices. It covers

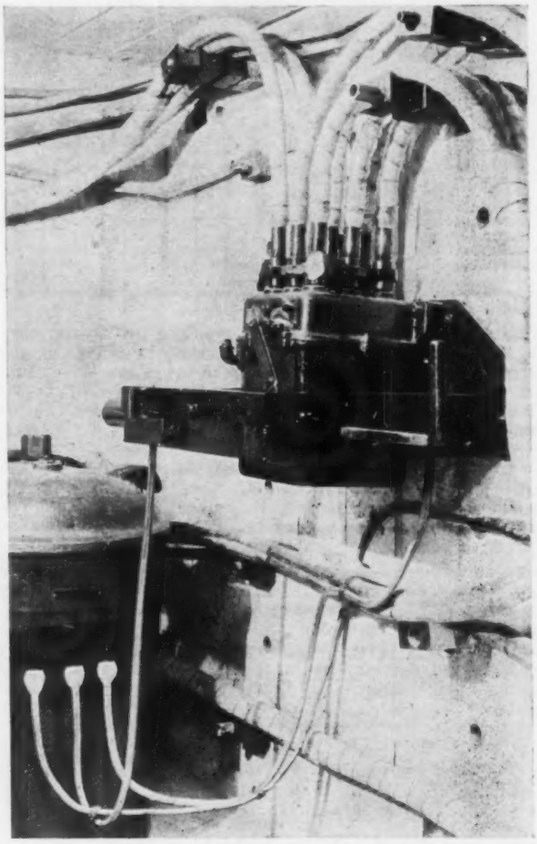


Fig. 3. Relays and potential transformers mounted in old transformer case.

the entire range from the extremely elaborate underground network systems employing automatic apparatus and translators down to the simple transfer from one secondary service to another by means of a manually operated knife switch. So far as is known there

is no network system (as it is understood in other parts of the country) in operation in California. This is due probably to the fact that system disturbances, which cannot be corrected by network systems, are inherently greater numerically than feeder or transformer interruptions in an area which might otherwise be so fed. However, as load densities increase and automatic equipment becomes more reliable and less costly it is possible that network systems may be found more economical to provide for those other causes of interruption mentioned above, than are the present systems. However, it is believed that a greater effort should be made to make the present equipment more reliable in preference to furnishing duplicate service, especially under Western system conditions.

Manual transfer of load is accomplished at present in many different ways. In underground systems the most common method employs underground junction boxes equipped with removable links which are operated after the interruption has occurred, since these boxes are not designed to operate under load. Because of this fact and to provide for those cases where feeders are cut out of service to permit maintenance, oil circuit breakers of the underground type are employed to interchange load. These are either single-throw or double-throw depending upon conditions. For instance, it often is desirable to make installations in industrial establishments or in other places where an attendant is always on duty. A double-throw switch occasionally is installed accessible to such an attendant who operates the switch as necessary. Single-throw switches also are so operated under a definite plan of procedure. Hospitals and theaters occasionally are furnished with a duplicate secondary feed controlled by knife switches and adequate only for emergency lighting in the surgical and operating rooms and in exits.

Where duplicate feeds are supplied to an individual consumer or a group of consumers it is customary to control the primary only and not to install duplicate transformers. Under present methods of inspecting and maintaining transformers their reliability is excellent and failures of large installations are rare. Installation costs and core losses as well as maintenance charges are greatly reduced thereby. Naturally there are numerous objections to the manual transfer of load between circuits especially where the transfer is made by means of junction-box links or by hand-operated oil circuit breakers installed in manholes in streets or alleys, especially since any failures are apt to occur just at the time when traffic is most congested. In such cases as much or more time may readily be consumed in operating the equipment as is lost by the interruption. This depends, of course, upon specific conditions.

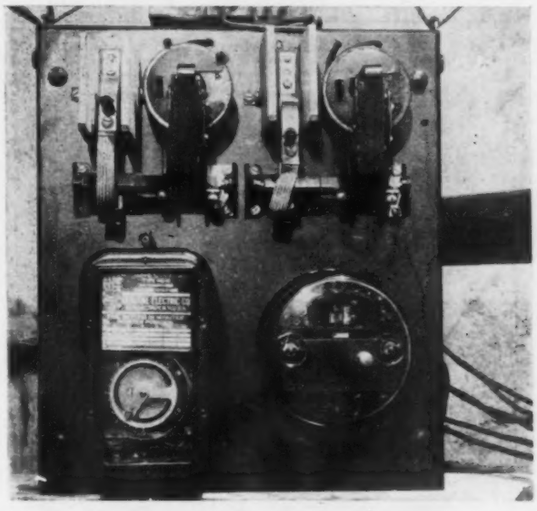


Fig. 4. Relay panel withdrawn from case. (See Fig. 3.)

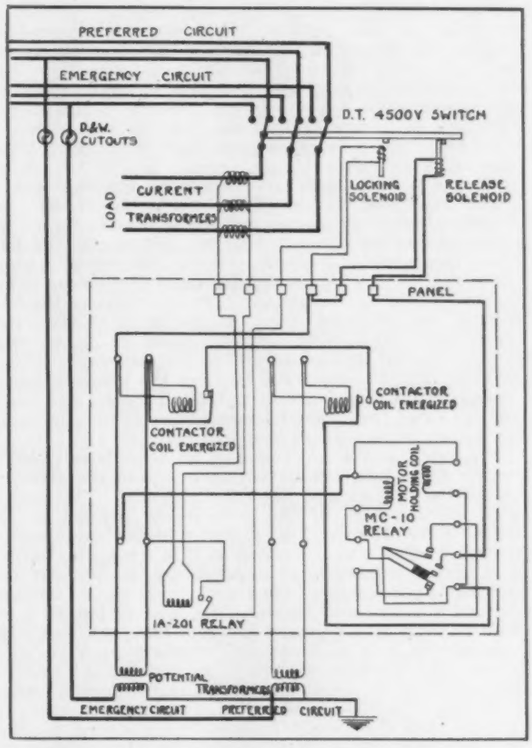


Fig. 5. Wiring diagram of automatic transfer switch.

Automatic transfer of load between circuits has introduced a great many problems, primarily because there appears to be little, if any, equipment on the market at the present time suitable for the manner in which engineers in this state desire it to operate. This may be due to the fact that equipment to operate at primary voltage is demanded, rather than at secondary voltage. For the most part, also, the equipment must be installed in manholes where space is at a premium and where the entrances are relatively small. As a result a number of equipments have been assembled or manufactured which appear to fill the requirements of the particular situations. Two of these are described and illustrated herewith.

There are several details which should be given consideration in the design of automatic throw-over equipment for underground installation, most of which have to do with the reliability of the equipment. It naturally is necessary that the equipment be water tight and that all connections be made in lead, wiped in. However, all mechanisms must be accessible and it should be possible to operate the equipment manually. Oil circuit breakers installed in underground vaults require inspection periodically and disconnecting provisions therefore are desirable. Any exposed moving parts should be treated to prevent rust. Above all, the en-

tire equipment must occupy a minimum of space in all three dimensions. As before stated, there appear to be few, if any, circuit breakers on the market at the present time which satisfy all these requirements and at the same time are reasonable in cost. It is hoped that the manufacturers may see a sufficient demand to justify developing equipment of this type.

Periodic inspections of this type of equipment are being made by the respective companies, generally at intervals of one month. However, experience has shown that the reliability is such that inspections can be made safely at considerably less frequency. One company, at least, finds it desirable to operate the equipment when inspections are made to insure correct functioning of the relays, the circuits being tied in through junction boxes at such times to prevent interruption to service.

Figure 1 illustrates an automatic transfer switch which has been developed by engineers of the Los Angeles Bureau of Power and Light for use on its underground system. It is designed to transfer the load from the preferred circuit to the emergency circuit when the voltage on the preferred circuit drops below 50 per cent of its normal value and to transfer the load back to the preferred circuit in two minutes after that circuit has returned to normal. However, no transfer is made in the first place unless the emergency circuit itself is normal. Figure 2 outlines the primary feeder scheme of the Los Angeles Bureau of Power and Light and indicates the manner in which the automatic transfer switch is applied to this scheme.

Figures 3 and 4 are views of an automatic transfer switch which has been developed in one of the divisions of the Pacific Gas and Electric Company. This switch does not have all of the refinements present in the switch illustrated in Fig. 1, but it does function in a perfectly satisfactory manner as it is used. It controls a group of transformers aggregating about 1,000 kw. serving an important downtown area which includes several theaters and hotels. The load is fed at 4 kv. four ways from a primary junction-box. Although the load served is in underground territory both the preferred and emergency circuits extend for a considerable distance on poles, although along different routes, from the substation. For obvious reasons it was not desired that the switch function as a circuit breaker and this fact was given consideration. In addition the same circuits which feed the area in question feed other load as well. In case of trouble on the overhead circuit it was required that the switch function to energize the particular downtown area from the emergency circuit, whereas if trouble were present in this latter area the switch should open to the neutral position so that the preferred circuit might be re-energized and also that the emergency circuit might not be tripped out.

These various requirements have been met in the switch shown and are clearly indicated in the wiring diagram, Fig. 5. All of the relays and potential transformer are contained within the transformer case shown in Fig. 3, while the arrangement of the relays is shown in Fig. 4, the panel having been removed from the case.

Operation is simple. If the preferred circuit fails, its contactor closes, energizing the MC-10 relay which is set to trip the transfer switch in 5 sec. If both circuits fail due to a system interruption, the MC-10 circuit remains open and the transfer switch does not throw over. If trouble is in the area controlled by the transfer switch the preferred circuit trips out and the MC-10 relay begins to function. Before it functions, however, the trouble has caused the IA-201 relay instantaneously to energize the locking solenoid and when the transfer switch is released by the MC-10 relay it is stopped in the open position by the lock. It may be noted that a single-element overload relay is used. Practically all underground faults at some time become single phase-to-ground faults and it therefore is believed that three overload relays are unnecessary. In 4 months the transfer switch has operated automatically but once and with entire satisfaction.

Training the Underground Force in Safety

By R. P. LUTZI*

Describes training of employees, lists cable splicers' tools and safety devices and discusses several items. Lists underground equipment and describes some of the devices and their use.

MOST utilities already have shown that they recognize that the human element is one of the important factors of the utility business and that certain specialized training must be carried out in order that

* Report prepared for the underground systems committee, Engineering Section.

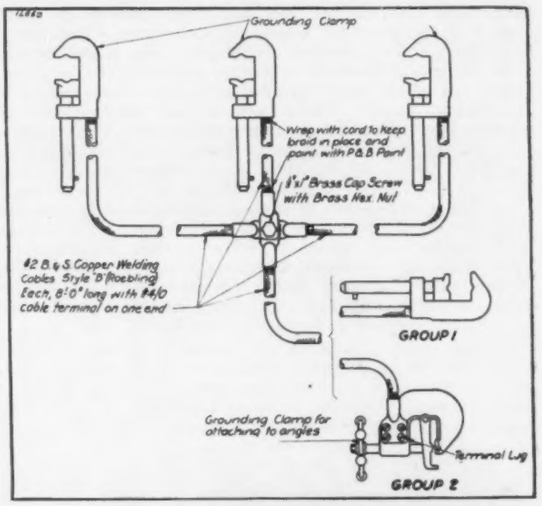

Grounding Clamp
Wrap with cord to keep braid in place and paint with P.&B. Paint
1/2" Brass Cap Screw with Brass Hex. Nut
#2 B. & S. Copper Welding Cables Style "B" (Flexible) Each, 8'-0" long with #4/0 cable terminal on one end
GROUP 1
Grounding Clamp for attaching to angles
Terminal Lug
GROUP 2

Fig. 1. Grounding device for station use.

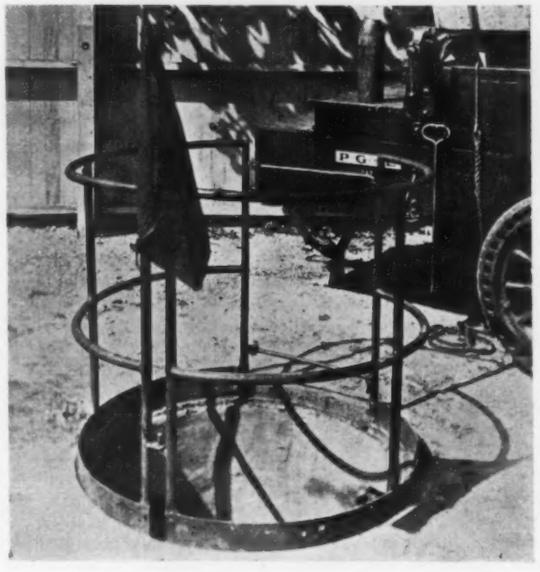


Fig. 2. Manhole guard rail.

they may hold their position in industry. Training of employees to do their work according to specification requirements is not complete unless they are taught to do it safely. It has been shown many times that most accidents attributed to unsafe conditions and improper practices could have been avoided if someone had thought and planned efficiently.

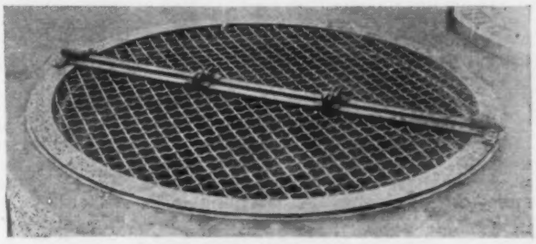


Fig. 3-A. Manhole guard screen.

It appears that most of the utilities have a definite plan for carrying on this training. The majority of the reporting companies seem to favor the idea of using the foreman on the job as the instructor, occasionally calling upon others for specific subjects. For promoting safety some of the companies depend upon certain individuals connected with their safety department for the majority of the training, this being followed up by the foreman who is continually on the alert regarding the safety of the men under him.

The question of centralized versus "on-the-job" training depends in a great measure upon the type and location of the particular work. Regardless of where the training is done it can be said that the constant warning against undesirable methods and unsafe practices does improve the job and reduce the number of accidents.

Foreman training is desirable because a good foreman is familiar with the fundamentals of his job and can portray to the men in a practical way the requirements for their particular work. Various methods, instructions and company rules are discussed at the foremen's meetings. In some cases the foremen are required to attend regular classes of training in their work where the company policies are presented. This is an ideal method as requirements and training thus are kept uniform and best results can be obtained.

Men must be taught to think, to be alert and to apply the knowledge that they possess at all times while performing their duties.

Most companies follow the practice of training their men to become proficient in the work of the various crafts, making them available for vacancies that arise. This is usually done on the job although upon some occasions when the demand is heavy it becomes necessary to form classes and give intensive instruction. An interesting paper on training cable splicers was presented before the P.C.E.A. underground committee by

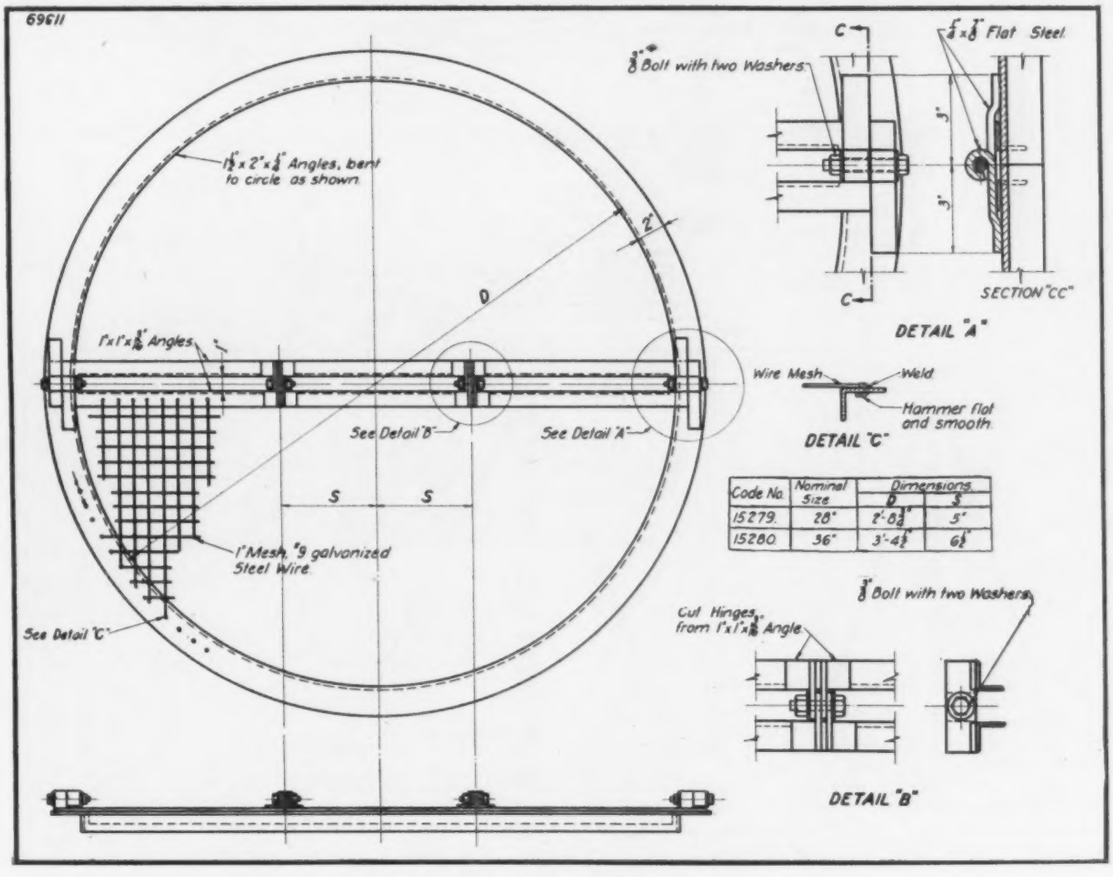


Fig. 3-B. Details of 28-in. and 36-in. guard screens.

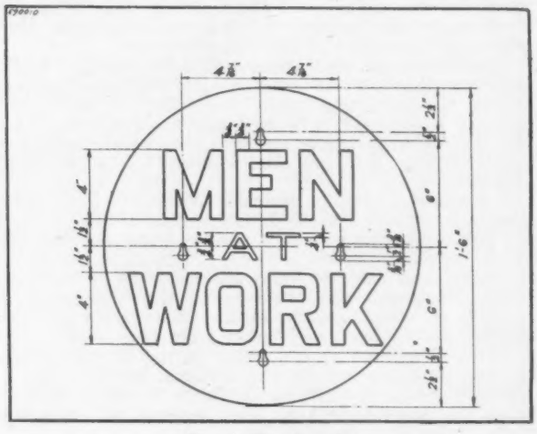


Fig. 4. Warning sign.

Paul E. Chapman and was printed in the 1925 Proceedings, page 79.

In the following paragraphs various equipment and methods are listed and commented upon.

Cable Splicer's Tools

Under this heading are listed the necessary equipment for a complete splicer's kit. Safety equipment and special underground equipment are covered later under separate headings.

This list includes all the tools necessary for any ordinary splicing job, and is made up from the reports of the various members of the committee. Additions and deductions may be made where the character of the work permits. Care must be exercised to keep the splicer's tool kit as light as possible in order that the cart may be handled readily. The tendency is to overload the cart and periodical inspection is necessary to do away with the accumulation of extra tools and materials.

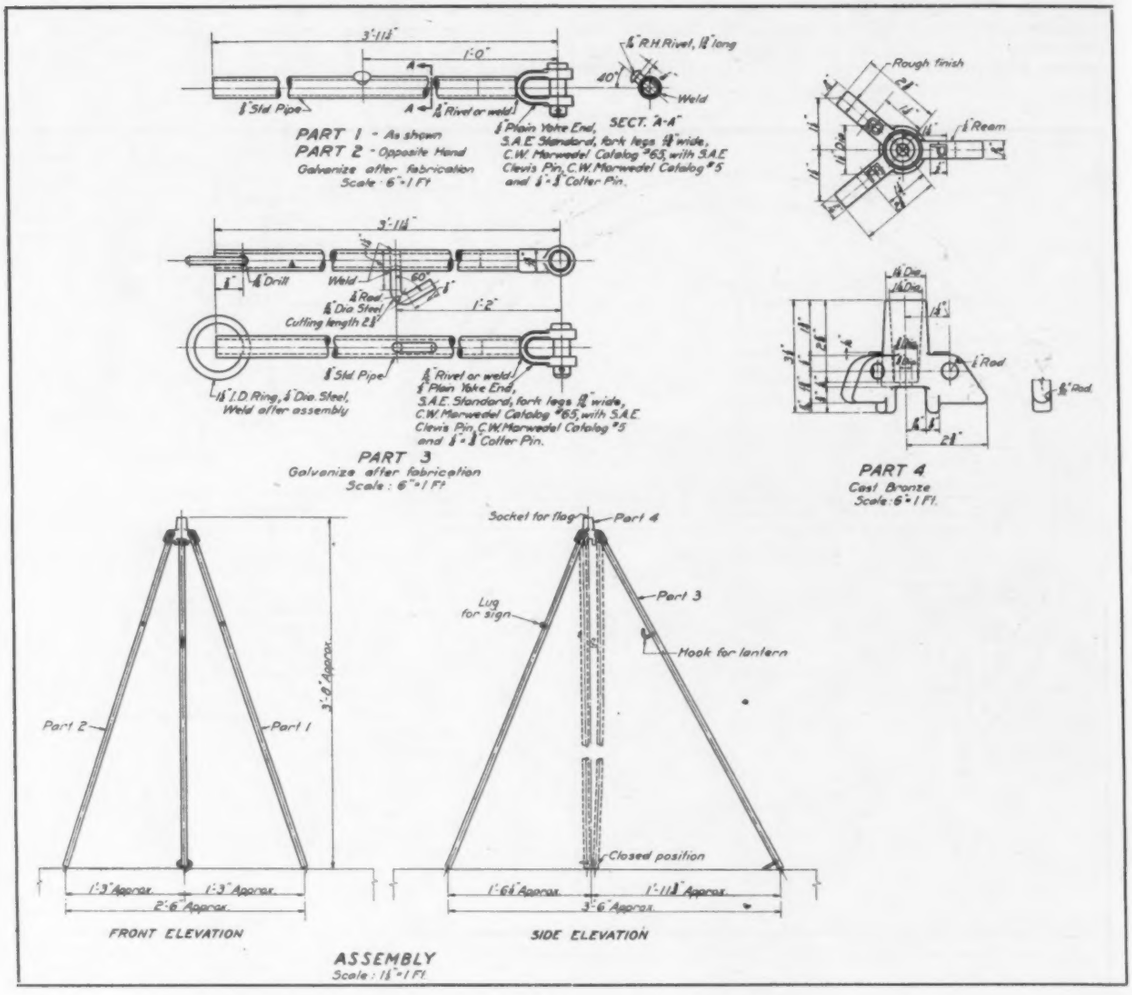


Fig. 5. Details of folding tripod-type warning-sign support.

Cable Splicer's Tools

1 tool cart
1 manhole cover lifting set
1 18-in. pinch bar
1 broom
1 short-handled shovel
1 splicer's tent
1 canvas 4x6 ft.
1 8-in. monkey wrench
1 10-in. monkey wrench
1 6-in. Crescent wrench
1 8-in. Crescent wrench
1 6-in. screwdriver
1 8-in. screwdriver
1 18-in. Stilson wrench
1 set socket wrenches
1 clawhammer
1 single jack
1 pein hammer
2 cold chisels
1 ¾-in. gad
1 set star drills
1 metal furnace
1 blow torch
2 plumbers scrapers
1 lead dresser
2 chipping knives
1 2-gal compound pot
1 2-qt. compound pot
2 hacksaw frames
1 14-in. compass saw
1 12-in. half-round bastard file
1 12-in. flat file
1 12-in. round file
1 12-in. half-round rasp file
2 8-in. sash tools
2 test lamps complete with 60-watt carbon lamp, socket, guard, test clips and 12-ft. lamp cord
1 ratchet brace with assorted bits and drills
1 funnel
1 3-in. ladle
1 4-in. ladle
2 12 x 17-in. drip pans
2 12-in. gas pliers
1 6-in. gas pliers
1 8-in. side-cutting pliers
2 8-in. metal pots
1 4-in. metal pot
1 5-gal. oil can
1 level (small)
1 tin snips
1 soldering copper
1 paint brush
1 hand-line and hook
1 3-in. pulley
1 set wiping cloths
1 small mirror
1 4-in. vise
1 wind shield for furnace

Safety Devices

Reporting companies have given considerable attention to safety devices. Rubber goods are well standardized and all report the use of gloves, blankets and protectors. Gas detectors and masks are found useful when working in localities troubled with gas. Also, the gas mask has been found valuable for allowing workmen to enter manholes after burnouts, enabling repairs

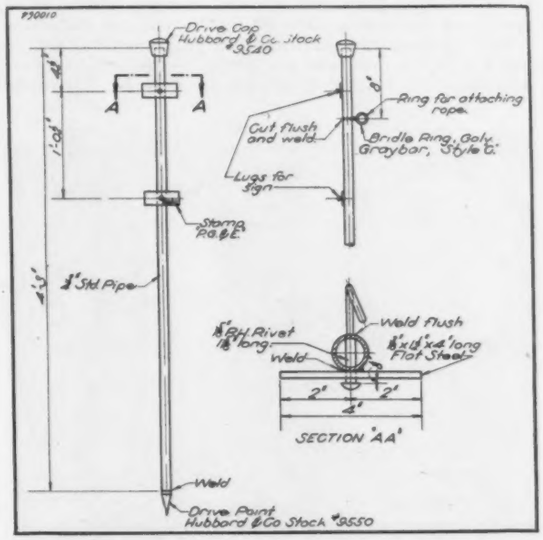


Fig. 6. Details of staff-type support for warning signs.

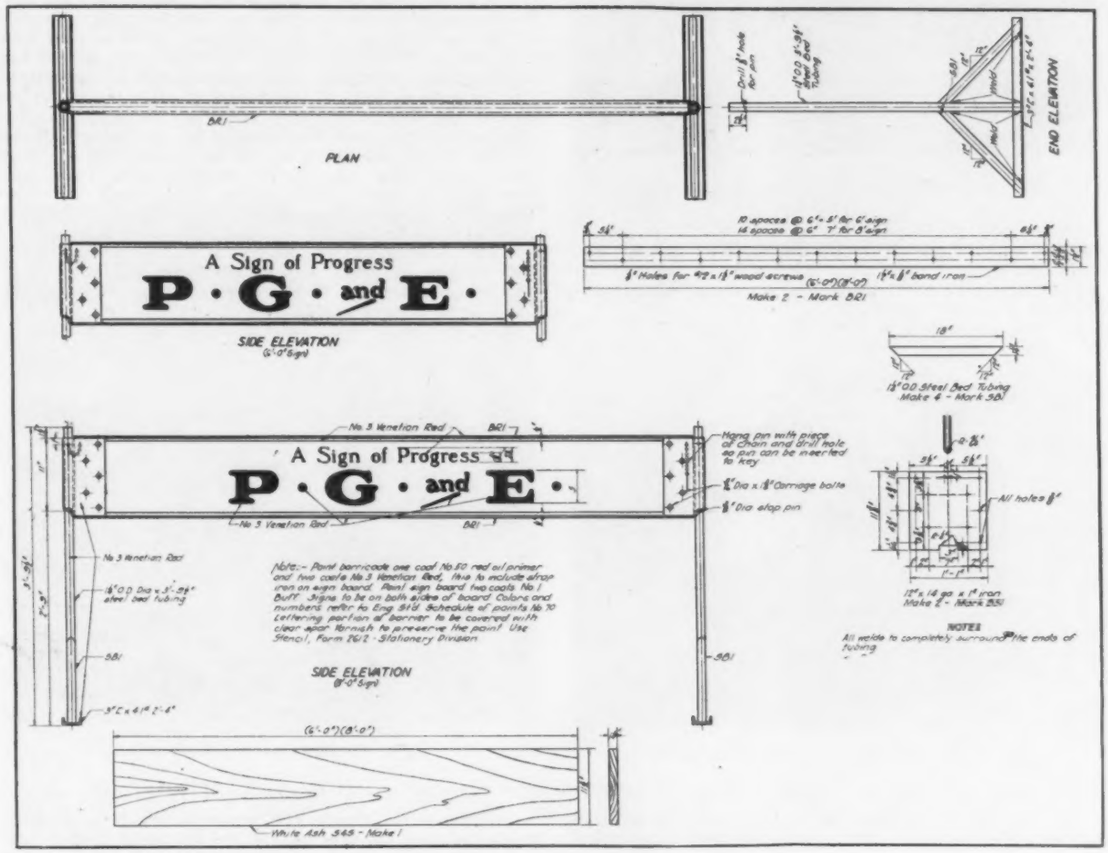

PLAN
END ELEVATION
A Sign of Progress
P · G · and E ·
SIDE ELEVATION
Make 2 - Mark B2I
1½" O.D. Steel Bed Tubing
Make 4 - Mark 9D
No 3 Venetian Red
Hang pin with piece of Chain and Drill hole so pin can be inserted to key
All holes ⅞"
Note:- Paint barricade one coat No 50 red oil primer and two coats No 3 Venetian Red, this to include strap iron on sign board. Paint sign board two coats No 1 Buff. Joins to be on both sides of board. Colors and numbers refer to Eng. Std. Schedule of paints No 70 Lettering portion of barrier to be covered with clear spar Varnish to preserve the paint. Use Stencil, Form 1612 - Stationery Division
SIDE ELEVATION
NOTE: All welds to completely surround the ends of tubing
White Ash 545 - Make 1

Fig. 7. Details of a portable trench barricade.

to be made quickly and without danger to the workmen from the fumes given off by the burning insulation.

Few companies report the use of grounding devices for use while working on cables when taken out of service. One in use is shown in Fig. 1. These are

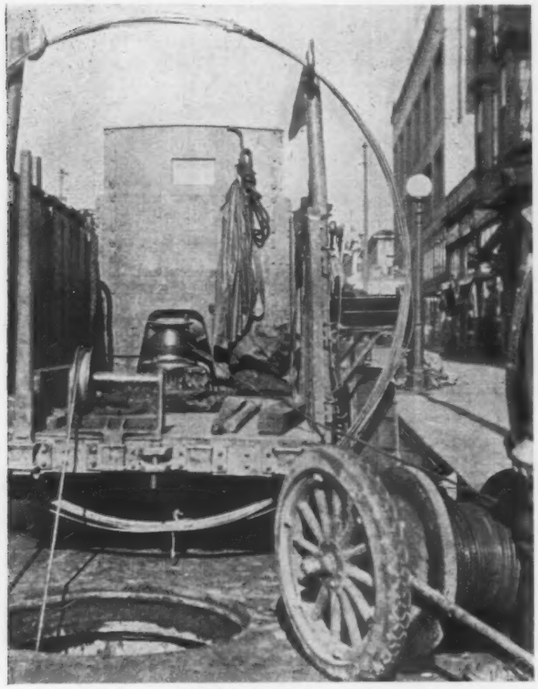


Fig. 8. Power take-off as used in underground construction.

placed on the conductors at the stations or sectionalizing points and grounded. Cutouts can be grounded by equipping an extra plug with a ground wire and inserting it in the cutout.

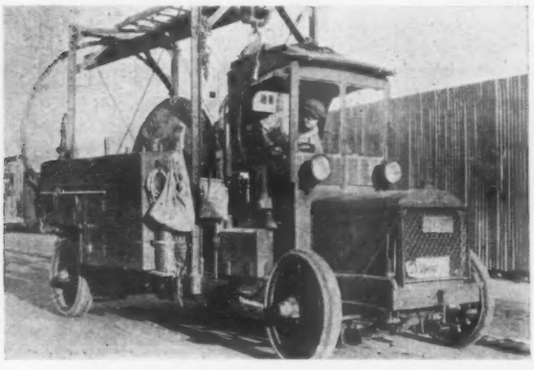


Fig. 9. General view of truck shown in Fig. 8.

The use of safety feet for ladders still is an open subject. Rubber, cork and carborundum feet are in use. The character of the work, as well as the location and surface on which work is being carried out are determining features which should be considered in selecting safety feet, otherwise a hazard may be created.

Operating tools of special design are made and used by the various companies and serve as safety equip-

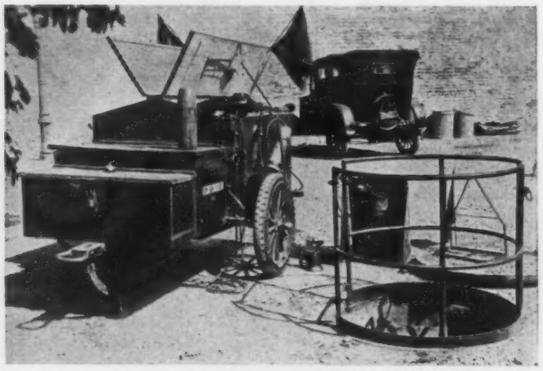


Fig. 10. Trailer equipment set up at a manhole.

ment. These are designed and used for the purpose of operating energized circuits safely.

Most companies have adopted either a pipe guard (Fig. 2) or manhole screen (Figs. 3A and 3B) for protecting open manholes while men are working. Tripods (Figs. 4, 5, 6, and 7) or standards with square base supporting a "man at work," "danger" sign, or red flag are used as a warning. The splicer's cart or tool wagon also is used as part of the guard, usually placed on the side of the hole opposite to the direction of traffic. The cart also serves as a work bench for the helper. Frame fences in conjunction with official barricades are used while manholes are under construction. On long trenches in heavy-traffic areas the trench is either fenced or bridged over to keep pedestrians from stepping over or falling in. Proper pedestrian lanes should be left open at convenient locations. Often traffic can be allowed to pass over excavations located at congested intersections while work is being carried on, by the use of proper bridging.

A safe way to determine a dead cable in a manhole

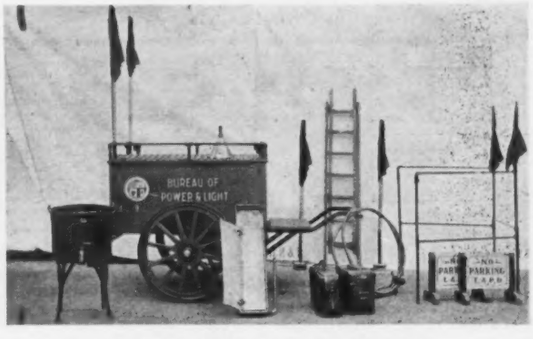


Fig. 11. Push cart and equipment.

is to test with a tone coil after locating its position from the duct location record and its identification tag. After this precaution is taken it is advisable to make

the first conductor contact by grounding or shorting the conductors.

A majority of companies do this by means of a spike (Figs. 17, 18 and 19) designed for the purpose. The spiking of the cable is done from the surface of the street thus allowing the workmen to keep in the clear of possible danger.

Safety Devices

Rubber gloves with leather protectors	Grounding device for use while working on cable
Rubber blanket 3 x 3 ft.	Gas mask
Gas detector	Barricades
Fire extinguisher	Manhole guards or screens
Lineman's protectors	Safety feet for ladders
Lineman's belt and safety	Cable testers (tone coil)
Red flags	Cable spikes
Safety signals	Special operating tools
Red lanterns	Goggles.

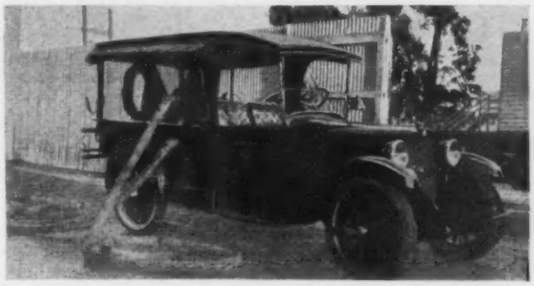


Fig. 12. Manhole pumping equipment.

Underground Equipment

Various types of trucks are used for underground construction. Class of work and special conditions have produced some well equipped apparatus. Some of the most useful are those equipped with cable-pulling devices or pumps using power take-off, also derricks for handling heavy apparatus. (Figs. 8, 9, 14 and 15.)

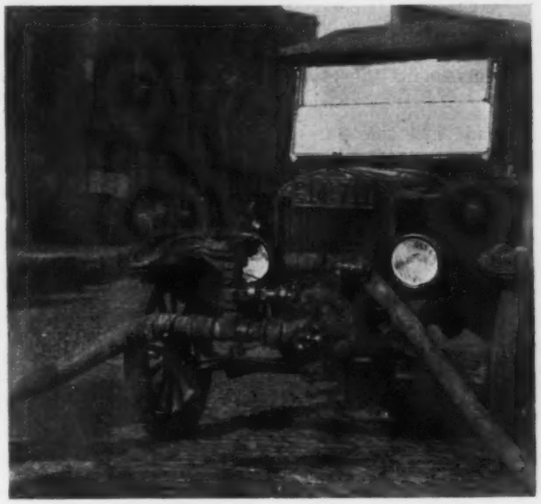


Fig. 13. Manhole pumping equipment.

Although there appears to be no particular standard, the various types presented meet the local conditions encountered with good results. Low-bed trucks are favored where heavy material is to be handled and, in conjunction with the derrick, chain blocks and power driven winch, they make loading simple.

Trailers both of the two-wheel and four-wheel types generally are used, especially for handling cable and heavy material. Several companies use the two-wheel type as a jack while pulling cable. Most companies report the use of winches for pulling cable, using power take-off from trucks. A few use tractors and one reports the use of a hand-winch. A standard cable grip generally is used for drawing in cable. However, various cable noses are used for special work. The split basket and soft hemp are favored for pulling out cables.

Ducts are fished by using duct-rods or a steel fish wire or oil-tempered spring-steel either flat or round and ranging in size from $\frac{3}{8}$ to $\frac{5}{8}$ in., depending upon the distance to be fished. Flexible steel tubing is used by a few for guiding cable through the manhole opening to the duct. This is advantageous for preventing damage to cable when pulling in congested

Fig. 14. Heavy crane on construction truck.

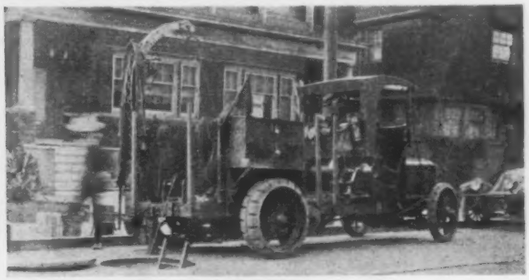


Fig. 15. Truck crane handling equipment from a manhole.

manholes. One company reports the use of air for fishing ducts. The equipment has not been entirely perfected as yet. Another useful tool is a take-up device for turning the reel when pulling out cable. This keeps an even tension on the cable and enables the workman to obtain a leverage on the reel, thus simplifying the work.

Portable pole platforms are used while installing cable terminals on pole work. They can be hung easily and assist the workman to a great extent.

Tool carts (Figs. 10 and 11) are designed and manufactured by the various companies in their own shops and usually are equipped with a draw-bar for trailing behind a truck. Some companies report the use of motorcycle carts for the use of crews on short jobs in scattered locations. The carts should be so constructed that material and tools are accessible, still keeping the equipment compact.

Fig. 16. Safety sheath punch.

Air compressors are used generally for breaking pavement and various cutting jobs in underground construction. They speed up the work and reduce construction costs. Compressed air can be used for many purposes as several air tools are now available, such as concrete breakers, spaders, sand rammers, jack-hammers, grinders, pumps, saws, and many other tools.

Earth augers and pipe jacks are found very useful for installing small pipes in locations where it is undesirable to open the streets. Crews trained in the use of these devices can overcome some very bad situations.

Welding usually is done in the shop, none of the reporting companies maintaining regular portable sets. In cases where cutting or welding cannot be brought to the shop temporary equipment is taken to the job.

Various sizes of concrete mixers are used depending upon the scope of the job. Several of the companies make use of pre-mixed concrete. This is found desirable in congested territory as few satisfactory locations can be found there for the materials.

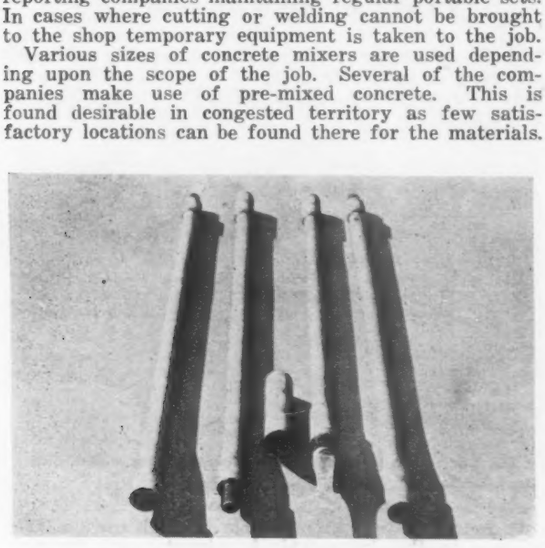


Fig. 17. Shaft extensions for safety sheath punch.

Manhole pumps (Figs. 12 and 13) are of every description, centrifugal, diaphragm, gear, etc. Some use power take-off from the engine driving the truck, others are driven by an independent gas engine or electric motor. Hand pumps also are in use. The most satisfactory equipment appears to be the pump mounted on the truck using the power take-off. This is advisable when it is necessary to do considerable pumping at various locations.

Cable fault locating is carried out in several ways. The majority of the companies use a patented fault locator with satisfactory results. The Wheatstone bridge, Megger, magneto and various interrupters also are used. One company reports the use of a 220-kv. Kenetron cable testing set.

Some manholes, due to close proximity of steam manholes or large transformer installations, become exceedingly warm. In order that workmen can perform their work properly and safely in these holes it is necessary to ventilate them. To do this portable fans are commonly used to blow the warm air out and to force cold air in. A strip of canvas hung in the manhole opening and projecting above and below the surface of the street and set at right angles to any breeze that may be blowing also provides effective ventilation. The cold air is forced down on one side and the warm air out the other. This arrangement will cool off the manhole as well as furnish a supply of fresh air to the workmen. In case of no breeze blowing the blower can be set in such a position that the same results can be obtained.

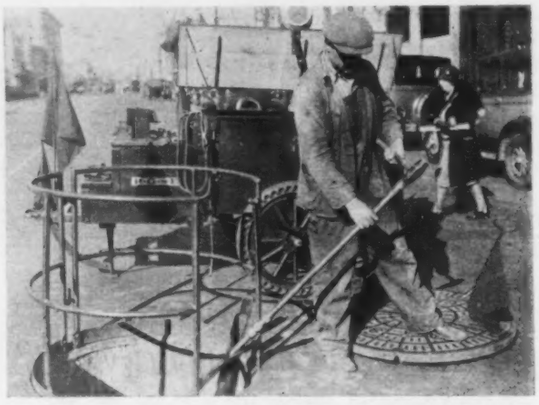


Fig. 18. Workman using safety sheath punch from outside of manhole.

Underground Equipment

Trucks	Voltmeter
Trailers	Bolt cutters
Tractors	Water canteen
Tool carts	Transformer dollies
Manhole pumps	Transformer tripods
Cable-pulling device (winch)	Magnetos
Cable grips	Wheatstone bridge
Cable noses	Telephone set with battery
Duct rods	Special wrenches (for transformer and cut-out nipples)
Fish wire (flat-round ⅝ to ⅝ in.)	Concrete mixers
Chain blocks	Concrete buggies
Pole platform	Concrete breakers
Step-ladder	Air spades
Extension ladder	Air tampers
Air compressor	Air grinders
Megger	Air drills
Pipe jacks	Electric drills
Earth auger	Trailer pulling cable
Welding outfit	Take-up device
Fault locating equipment	Steel flexible tube for guiding cable to duct when pulling
Cable-testing equipment	Phasing transformer
Phase rotation	Manhole fans and blowers
Thermometers	First-aid kit.
Polarity indicators	

Immersion Prevention for Subway Transformers

By S. G. BOWMAN*

An outline mehod used to prevent damage to subway transformers due to submersion in flooded manholes.

GENERAL practice of power companies operating on the Pacific Coast is to install small subway-type transformers on manhole floors and depend upon tight joints and gaskets of transformers to withstand submersion. However, of nine companies investigated, three report that in special cases where water conditions are bad, small subway transformers have been installed on angle-iron or pipe frames at sufficient height to elevate the transformer cover as near the top of the manhole as is possible.

One company reports that its practice is to make a test for leaks when installing the transformer. The other companies report that no tests are made other than inspecting the condition of gaskets and terminals to ascertain that they are properly tightened. In view of this, transformer failures due to water leaking in while submerged are very rare. Two companies report two failures each, and seven companies report none.

* Report prepared for the underground systems committee, Engineering Section.

Identification of Cables in Manholes and Vaults

By PAUL SURANSKY*

This report analyzes the problem of identification of cables in manholes and vaults. It explains what a system of identification should consist of and gives examples of typical existing systems used by utilities in California.

UNDERGROUND distribution systems are growing larger and existing manholes and vaults are becoming more congested each day. With such conditions confronting the operating utilities it is essential that some systematic means for the positive identification of cables be employed. This is necessary so that the cable splicers and other workmen may identify readily and without error the particular cable that they are ordered to work upon.

Upon analyzing the subject, it appears to resolve itself into three parts, nomenclature of circuits, tagging of cables, and identification from office records.

Nomenclature of Circuits

Nomenclature of circuits, as used here, means a systematic scheme for assigning names or numbers to underground circuits. In working up a system of nomenclature the future growth of the underground system in question should be considered. Provision should be made not only for existing circuits and new circuits of the present classes, such as street-lighting circuits, 4-kv. circuits, etc., but also for new classes of circuits that may be added in the future.

The name or number assigned to a circuit should indicate (1) the class or type of circuit, such as d.c., 4-kv., 11-kv., etc., (2) the station from which it emanates, such as stations A, B, C, No. 12, No. 20, etc., and (3) the position it occupies in that station such as 2, 11, 15, etc.

The results of questionnaires sent to nine operating utilities of California indicate that some of the utilities have given careful consideration to this subject. Some

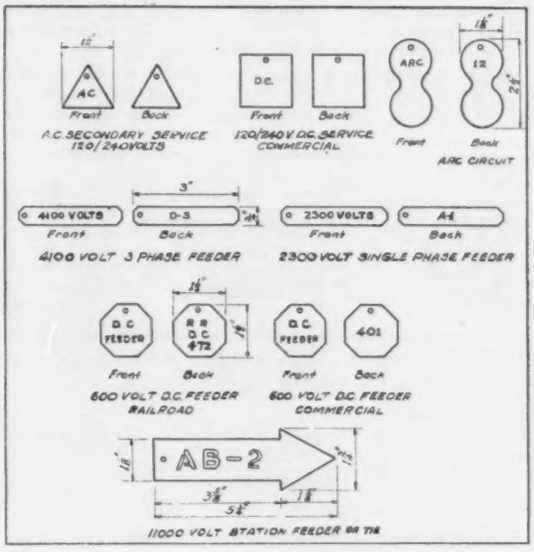


Fig. 1. Cable identification tags.

utilities have not given the consideration that they should. In order that the latter utilities may have something to guide them, two typical systems of nomenclaure now being used are outlined in the following paragraphs.

Identification System "A"

In this system numbers are assigned to the stations.

Direct-Current Circuits—220-volt d.c. feeder circuits are named by the point of termination of the feeder, for example: "Third and Broadway," "Sixth and Main," "Evening Herald." 220-volt d.c. mains derive their names from the location of junction boxes which they

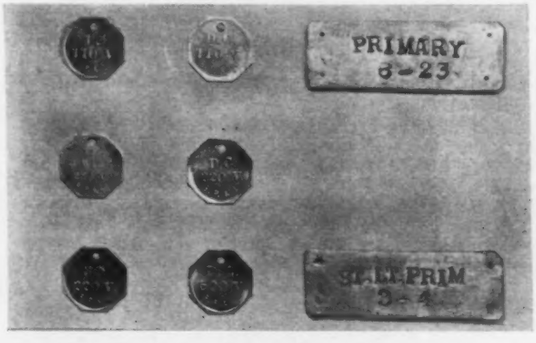


Fig. 2. Cable identification tags.

connect and the street served, as "Third and Broadway," Broadway—Third to Fourth," "Main—Fifth to Sixth." These names are abbreviated where possible. For instance, "Third and Broadway" is written "3-B';" "Broadway—Third to Fourth," is written "B-3-4;"

* Report prepared for the underground systems committee, Engineering Section.

"Main—Fifth to Sixth," is "M-5-6," etc. 500-volt d.c. circuits are designated by voltage and feeder number, thus "500 v. No. 8."

2.3-kv. and 4.6-kv. Circuits—These circuits are known as "primaries." Each circuit carries a number which indicates the station source and the primary number, as "Primary 12-25." The first number, 12, indicates that the primary comes from station 12 and occupies primary feeder position No. 25 in that station.

33-kv. Transmission Circuits—Names of these circuits are derived from the stations that they connect. For Example, a circuit connecting two stations named

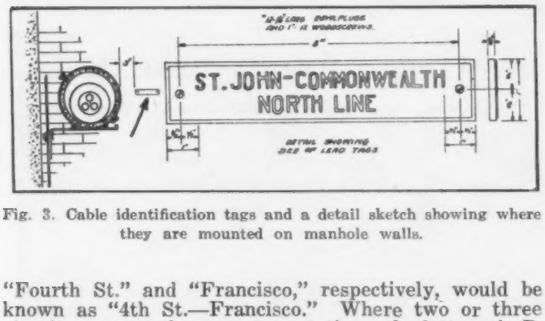


Fig. 3. Cable identification tags and a detail sketch showing where they are mounted on manhole walls.

"Fourth St." and "Francisco," respectively, would be known as "4th St.—Francisco." Where two or three circuits connect the same two stations, the letters A, B, and C, etc., indicate which of the circuits is meant, as "4th St.—Francisco circuit B."

Street-Lighting Circuits—Series circuits are numbered to indicate the station source and the street-light circuit position in that station. In the name "St. Lt. 5-14," the 5 indicates that the circuit comes from station 5, and the 14 indicates that it occupies position 14 in that station.

For multiple circuits a 4.6-kv. primary feeding a large number of constant-current transformers and switched either at a station or at a remote point is known as a "street-light primary" and carries a number which indicates the station and the primary feeder position to which it is connected. For example "St.Lt. Prim. 6-7" indicates a switched 4.6-kv. street-light primary feeding from station 6, primary position No. 7. 110-volt and 200-volt multiple street-light circuits are known as "St.Lt. Secondaries."

Miscellaneous Circuits—Special types of circuits for specific purposes are known by names characteristic of the service. For instance: "D.C.Pressure," "Traffic Signal," "Communication and Control," etc.

Identification System "B"

In this system letters of the alphabet are assigned to all stations.

Direct-Current Circuits—These circuits are all in the 100 series, the d.c. circuits leading out of station "A" would be 101, 102, 103, etc, and out of station "D" would be 401, 402, 403, etc. The first digit indicates the station from which the circuit emanates, 1 indicating station "A" and 4 indicating station "D." The third digit indicates the position of the circuit in that station. On d.c. railway feeders the second digit is always a 7. For example, those out of station "A" would be 171, 172, etc., or those out of station "D" would be 471, 472, 473, etc.

4-kv. Distribution Feeder Circuits—These feeders leading from the distribution substation to the manholes, etc., are designated by the name of the station from which they emanate and a number. For example, 4-kv. feeders leading out of station "A" would be known as "A-1," "A-2," etc., or out of station "D" would be "D-1," "D-2," etc.

11-kv. Station Feeder Circuits—These circuits are designated by the names of the interconnecting stations. The name of that station from which the current is fed comes first. An example being an 11-kv. circuit from station "A" going to station "B" would be known as "AB-1." If another circuit were to come from the same station it would be known as "AB-2." Similarly, circuits tying in stations "D" and "F" would be known as "DF-1," "DF-2," etc.

Street-Lighting Circuits—With series circuits the station from which the service comes is designated by a number. For instance circuits coming from station "A" would be known as 11, 12, 13, etc., the first digit indicating station "A" and the second digit the number of the street lighting circuit in the order which it was installed in that station. Those coming out of station "D" would be known as 41, 42, 43, etc.

For multiple circuits, a 4-kv. primary feeding a large number of constant-current transformers and switched at a station is known as a street-light primary and

STREET SO. BROADWAY MANHOLE NO. 224
COVER

LOOKING NORTH — DUCT SIZE & KIND: 4" F.C.			
11	12		14
21	22	23	24
	32	33	34
41	42	43	44

LOOKING SOUTH — DUCT SIZE & KIND: 4" F.C.			
11		13	14
21	22	23	24
31	32	33	
41	42	43	44

DUCT	CABLES NO.	CABLES SIZE	DESCRIPTION	DUCT	CABLES NO.	CABLES SIZE
11	1	500M-3C	PRIMARY 12-5	14	1	500M-3C
21	1	500M-3C	PRIMARY 12-7	24	1	500M-3C
41	1	2/0-3C	PRIMARY	44	1	2/0-3C
12	1	#6-3C	ST.LT. PRIMARY 12-25	13	1	#6-3C
23	1	#6-4C	ST.LT. 12-1 & 12-2	22	1	#6-4C
42	2	1000M-1C	220V A.C. 1φ	43	2	1000M-1C
43	3	500M-1C	220V A.C. 3φ	42	3	500M-1C
43	1	500M	NEUTRAL	43	1	500M
34	2	500M-1C	220V D.C.- MAIN	31	2	500M-1C
14	2	1000M-1C	220V D.C.- 2-B	11	2	1000M-1C
24	2	1000M-1C	220V D.C.- 1-B	21	2	1000M-1C
44	2	4/0-1C	550V D.C. #2	41	2	4/0-1C
22	1	56C	COMM. & CONTROL	23	1	56C
32	1	#14-2C	PRESSURE	33	1	#14-2C
33	1	10-C	TRAFFIC SIGNAL	32	1	10-C

Fig. 4. Identification of cables from office records.

carries a number which indicates the station and the primary feeder position it occupies in that station. For instance street-lighting primary 11 indicates that it is fed out of station "A" and occupies street-light primary position No. 1 in that station.

Tagging Cables

Tagging a cable involves either the attachment of a metallic tag, with the name or number of that cable stamped thereon, directly to the cable by means of a wire or the placing of such a tag adjacent to the cable so that by consulting it the cable that it refers to can be identified definitely. Satisfactory tags may be made from brass, aluminum or the lead sheathing of scrapped lead-covered cables.

Suitable means for attaching tags directly to the cable may be made by using tinned or non-tinned brass wire or tinned copper wire. These wire attachments should resist whatever corrosive effects that may exist due to moisture conditions in the manhole or vault. Tags not attached directly to the cables may be mounted in the manholes by installing wood plugs in the manhole wall and fastening the tag to it by means of wood screws.

One of the utilities in California uses tinned brass tags made in different shapes. Each shape indicates the kind of current carried by the cable to which it is attached, indicating whether it is direct current or alternating current and also indicating the class of circuit, whether it is street lighting, 4-kv., 11-kv., etc. By this means the cable splicer or workman can tell readily the type of circuit without reading the tag. However, to know what the name of the circuit is he must consult the tag. Some of the tags are made of such shapes that they will command attention immediately. This is illustrated by the arrow-shaped tag for 11-kv. circuits as shown in Fig. 1. Other tags used by California companies are shown in Figs. 2 and 3.

Good practice calls for the tagging of all cables in all manholes. Service cables should be tagged in the manhole with the house number stamped on the tags.

Indentification From Office Records

It often is necessary in issuing orders to workmen to identify cables in manholes and vaults from the office records. There are two general types of such records used by utilities in California. One record consists of manhole sheets (not on maps) which indicate the duct section, size and kind of ducts, the ducts occupied and give a complete description of all cables passing through the manhole. This is illustrated by Fig. 4.

Numbers are assigned to each duct. These duct numbers really are code numbers representing the position of the individual ducts with respect to the duct section, the first digit indicating the number of the row of ducts, counting from the top, the second digit indicating the position in a given row of ducts counting from the left. For example, duct 44 means the fourth duct from the left in the fourth row from the top. The direction in which the duct in question leaves the manholes is indicated by the customary points of the compass, as N-E-S-W. Any cable thus may be located specifically by referring to the manhole, the direction in which the cable in question enters or leaves the manhole, and the position of the duct with respect to the duct section. Thus a cable splicer going to work on primary 12-5 in manhole No. 224 on South Broadway (see Fig. 4) will be told that the cable is in duct 11 north (abbreviated D-11-N) and duct 14 south (abbreviated D-14-S). He then can locate the cable without maps or cable tags.

INSERT FIG 5

In the other type of record a cross-section of each duct line is shown on the duct-line maps. (See Fig. No. 5.) These cross sections are taken looking either north or west. Each cable, with its name and size, is shown on the map in the duct it actually occupies. Thus "AB-2" in manhole No. 6 at Third and Twentieth Sts. (see Fig. 5) is shown in the "north" duct section (looking north) in the second duct from the left in the top row and in the "east" duct section (looking west) in the second duct from the left in the top row. Thus by consulting the duct-line maps a complete identification of any cable can be made.

Both systems of office records appear to have their merits. However, before any utility adopts either system, local conditions should be given careful consideration to determine which system will best fit its needs.

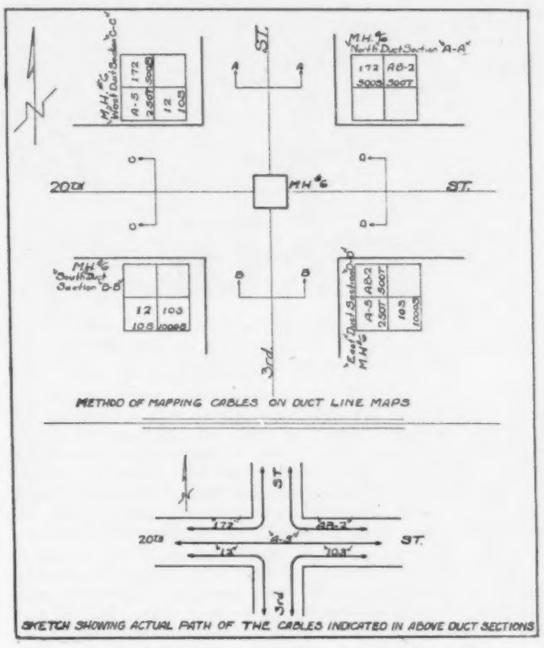

ST.
20TH
ST.
3rd.
METHOD OF MAPPING CABLES ON DUCT LINE MAPS
SKETCH SHOWING ACTUAL PATH OF THE CABLES INDICATED IN ABOVE DUCT SECTIONS

Fig. 5. Identification of cables from office records.

Conclusions

Underground distribution systems are growing rapidly and as they grow the manholes and vaults will become more congested. Thus it becomes a necessity to have some systematic scheme for identification of cables. Any utility adopting a new system of identification or intending to revise or modify its present system should give careful consideration to all phases of the problem. Any system adopted should be flexible enough to take care of any conditions that may arise because it is expensive to discard an old system and put a new one in its place.

Transformer Loading and Load Measurement

By H. H. BUELL*

AS IS the case with most problems which are met and studied in business there are two factors involved in the study of transformer loading, the first being that of economics and the second that of service. Perhaps one should say "the one" and "the other" rather than "the first" and "the second." It is not within the province of this committee to determine which of the two factors shall be considered of major importance. A thorough study of the problem, however, should result in a better understanding of both factors and enable them to be weighed properly.

After even a brief consideration of the matter it is evident that the subject involves far more in the way of research and field investigation than is possible within the period of one year and that a limitation must be set for the year's work in order possibly to

* Report prepared for the underground systems committee, Engineering Section.

reach a conclusion worth while. This seems to be only a logical plan since this year's subcommittee is merely continuing the study which was began last year, or at least was included in the report of the overhead system committee of 1927-1928. The actual study of the subject has been going on for years among the engineers of the various utilities in the P.C.E.A. The report of last year consisted, to a large extent, of theoretical curves derived from assumed loadings of transformers applied to the known characteristics of those transformers, together with a relatively few studies made in the field.

The economics and the service requirements of this problem are represented by the heating of the transformer due to its load and to the regulation of the transformer due to the same cause. In other words, the effort is to install as small a transformer as possible which will not burn up due to the load impressed on it and yet will give a reasonably smooth voltage curve as indicated on a recording voltmeter chart. In this investigation are considered the effects of the average electric range and water heater installations when combined with lighting and/or line-start motors which are coming more and more into general use.

From a brief preliminary survey it appears very much as though the electric utilities may find it necessary to issue rather stringent rules on the use of the present line-start motors now being sold, in order to protect their service. All utilities pride themselves on providing a service of the highest order and certainly can object to equipment which practically makes it impossible to deliver that type of service in all cases. This study will be confined entirely to field surveys under actual working conditions because of the extreme difficulty of duplicating such conditions in the laboratory. It is true that possibly a longer time will be required to arrive at a definite conclusion, but the conclusion may be more valuable to the practical engineer.

Regulation is affected by the periodicity of the load as well as by its magnitude. It is well known that a small motor, ⅛ hp. or less, operating a refrigerator compressor, for instance, produces fluctuations in voltage, merely in the service, which are objectionable to a person reading. In the type of load under consideration the change in voltage is of larger value, but occurs only at the relatively infrequent periods that the load is turned on or off. In the area being studied the water heaters, for instance, are of 5-kw. capacity in practically all cases. Turning on 5 kw. at once produces a voltage change which is far more appreciable to the eye than would be the case if the same amount of load were turned on in small increments of the order of 500 watts, although the final voltage change is the same in each case.

Up to very recently, also, the lack of a reasonable balance of the elements of electric ranges has been the cause of a variation in voltage at the service which appeared unreasonable for the amount of load involved and for the large service ordinarily installed, a real factor to consider. The present so-called load-balancing switches probably have improved the conditions somewhat. It should be born in mind also that regulation is a function of transformer impedance, and that lower-impedance transformers than now are being used would have the effect of improving voltage regulation in the cases under consideration, but the cost of the transformers would be increased, thus again introducing the matter of economics.

The measure of regulation is a very difficult matter and no company seems to have a standard upon which to base the permissible values of voltage variation. It seems to be common practice to consider each case individually. In other words the matter comes down to the regulation to which the individual is accustomed and which he considers proper. This in turn is a matter of the education of the individual consumer by the company which supplies him with electric service. As before mentioned all companies are supplying a very high class of service, continuous, with very few interruptions and with almost ideally uniform voltage over the entire 24 hours. A consumer that has been supplied lighting service only from an individual transformer on a properly regulated circuit has a different conception of good service than one who has been supplied with combination heating and cooking service together with a motor operating a reciprocating deep well pump, for instance.

The matter at the present time is further complicated by large numbers of 1,000-watt and 1,250-watt heaters being connected directly to lighting services fed through small wire in the residences and at the ends of relatively long secondaries. These are conditions which require that the distribution engineer not only be continually on the alert, but they also require careful study of the economics of the situation and possibly a slight change in the consumer's idea of service, at the same time bearing in mind that even slight reductions in voltage reduce revenue in such installations.

The heating of the transformer in the cases under consideration is due to the serving of relatively small loads for long periods of time and of large loads for short periods of time as well as infinite combinations of

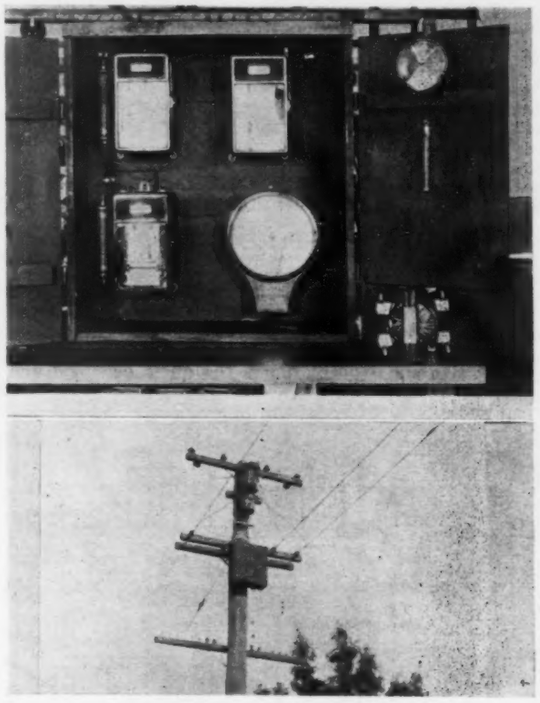


Fig. 1. Test equipment for studying transformer loading in the field (above) and test equipment mounted on pole and connected to a transformer (below).

both conditions. In addition there is the matter of diversity brought about by the installations in large buildings and large apartment houses. It is true that experience has indicated a reasonable diversity factor for installations of this type, but many engineers have found that even smaller transformers can safely be installed than are indicated by these diversity factors.

It also appears possible that extremely large loads, several hundred percent of the transformer capacity, can be supplied for very short periods. These do not indicate through excessive oil temperature, but if applied often enough and over a long enough period of time will cause failure of the insulation at the "hot

spot." The effect of ambient temperature on transformer capacity and the tendency to put smaller transformers into service on air-heating installations where the load is used only when the ambient is low, is another factor in the study.

In an effort to standardize upon equipment and to determine the practice of the various companies a questionnaire was circulated. The replies so far received indicate a fairly uniform practice in the installation of transformers for the various sizes of equipment connected. However, two of the replies show that possibly the engineers either believe that transformer regulation is of considerable moment or they consider the demand factors on this type of equipment considerably higher than do others. For instance, the majority of those replying to the questionnaire install a 3-kw. transformer on the average 7.5-kw. range and lights, while others install a 5-kw. transformer for the same load. The majority install a 5-kw. transformer for the average range, 4-or 5-kw. water heater and lights, while others install a 10-kw. transformer for the same load. Those who install the larger transformer undoubtedly will find that the small transformer would have carried the load easily and that the regulation of the transformer was only a small fraction of the total voltage drop. This study should be helpful in clearing up these points.

As to equipment suitable for carrying on the studies in the field, there are many different types to select from. Each company has its own methods and all probably arrive at the same conclusions. Most companies rely to a large extent upon surveys made by means of mechanical temperature indicating devices and recording or indicating ammeters in connection with split-core current transformers. Recording voltmeters have been largely used for making voltage studies.

With this broad preliminary statement of the theory of the problem consideration will be given to the methods employed at present in continuing the work outlined by the 1927-28 committee. As already stated above the method used is practically the same as employed before but includes also the measure of the additional feature of transformer regulation.

Test Equipment

In Fig. 1 is shown clearly the types of instruments used and the method employed in mounting them in order to secure the desired readings. The recording instruments are mounted in a portable box or cabinet and consist of two recording voltmeters indicating primary voltage and secondary voltage of the transformer under test, a recording ammeter indicating the load on the transformer, and a recording thermometer indicating the exact temperature of the oil at the top of the transformer. In addition a maximum-reading thermometer hung on the outside of the box indicates the maximum air temperature while another device registers the maximum temperature reached by the oil in the transformer, expressed in terms of percent of transformer capacity. To obtain the primary voltage, a potential transformer in the form of a small distribution transformer is included in the equipment while the load on the transformer is secured through a three-wire current transformer connected directly in the transformer secondary leads by means of the lugs regularly used for such connection. It is true that this method does not account for unbalance in the transformer secondary and to that extent is inaccurate, but it does measure the entire output of the transformer. The current transformer is varied with the size of the transformer.

It may be considered by many that too much importance is being attached to the regulation of the transformer and not enough to the voltage drop in the secondary and service between the transformer and the meter board, that the former in fact may be so small in relation to the latter as to be almost negligible. In order to make the study complete and cover this particular point as well, a recording voltmeter placed at the meter board indicates simultaneously the delivered voltage.

There is still another factor which should not be overlooked. It is a well known fact, at least in one company, that 75 per cent of those who at first install electric ranges only install electric water-heaters within a year thereafter. It is considered economical therefore to install a transformer of adequate size for both in the first place, even although a small proportion will not make the entire installation.

In the final analysis an effort will be made to interpret the effects of voltage regulation of the transformer and service as observed by the eye. There are possibly several ways in which this could be done. The effect of reduced voltage on lamp candle-power has been selected as the method which will more clearly illustrate the point. After all, this is the only way in which sudden voltage changes are indicated to the individual consumer. Accordingly a manufacturer's curve showing the percentage of lumens variation in lamps with variations in voltage will be employed and the results in the actual installation will be plotted. It is well known that reductions in voltage of only 5 per cent for instance, will reduce the candle power of incandescent lamps practically 15 per cent. It is, of course, appreciated that these values are only relative and that the individual consumer's reaction is the only basis by which regulation can be judged.

In carrying out the plan of attack outlined above, studies were made of at least six installations, each being selected as nearly typical of its class as possible. These included, for instance, a range-and-light installation with an average family; one with range, water heater and lights connected; another with water heater and lights only, and so forth. It was found to be very difficult indeed to secure complete sets of charts under what might be considered average conditions.

For instance, one family decided to have a lot of floor sanding done while readings were being taken and another left town right in the midst of the readings. Since the set-up, while simple, represented some expense frequent changes were to be avoided if possible. It was found also, because of severe cold weather, that frequently one or more of the clocks stopped during the process of securing readings, thus necessitating repeating them. For these reasons it has been impossible to secure sufficient data up to the present time from which definite conclusions may be drawn, and the results therefore may be considered as qualitative rather than quantitative.

Each individual type of installation was supplied with service from three or four different sizes of transformers and a sufficient number of readings taken on each size to satisfy all the requirements. For instance, where it has been customary to install a 5-kw. transformer on a range, water heater and light service, there also was installed a 7.5-kw. transformer, a 3-kw. transformer, and in some cases even a 1.5-kw. transformer. For convenience only these installations consisting of a transformer and service were studied, thus simplifying the conditions. As a matter of fact, it is customary in suburban territory to reduce the secondary run to a minimum.

It was apparent very early that either installations had been selected where the use of the appliances was very infrequent, which hardly seemed likely in all of the cases studied, or that the original ideas of transformer sizes required were incorrect. As a matter of fact, in none of the cases studied did the recording thermometer indicate higher than 100 deg. F. at any time during the 24 hours, nor did the needle on the mechanical temperature indicator register at all. However, there was no question but what the voltage drop in the transformer, especially with the smaller sizes connected to the larger loads, represented a very considerable part of the total voltage drop between the primary line and the meter board.

These qualitative results were studied and several possible methods of approach suggested themselves. For instance, it might be considered economically practicable to increase the size of the wire in a service to the point where the drop in the small transformer supplying the service is very small relative to the total drop. This however would introduce difficulties in supporting the service because of its weight and, in any event, the increased cost of the service might readily be greater than the saving in transformer cost. Accordingly it was believed that consideration might be given to the characteristics of the transformer itself to determine whether or not the solution might be found there.

It is a well known fact that during the past 20 years transformer manufacturers have made great strides in perfecting their product and in reducing the losses. It is interesting to note however, that while transformer core losses or all-day losses have been practically cut in half, the copper losses have remained almost constant and, since regulation is a function of copper loss, that core losses thus have been reduced at the expense of regulation. This point seems to be one worth contemplating. For instance, it may be apparent as far as regulation is concerned that a 7.5-kw. transformer is required on a certain installation but that a 3-kw. transformer is adequate to carry the average load on the basis of heating effect. Should it not be possible, at least theoretically, so to re-design the 3-kw. transformer that its core and copper losses are the same as the 7.5-kw. transformer and its regulation therefore the same as the 7.5-kw. transformer, but its cost remains the same or practically the same as the original 3-kw. transformer.

It is appreciated of course that practically there may be all kinds of difficulties in the way of such a scheme and that even its suggestion savors of heresy. It may even be, because of the present type of "iron" employed in the core, that the exciting current may be abnormal and yet, if we would ordinarily employ a 7.5-kw. transformer because of regulation, we should be willing to permit in the smaller transformer the core losses and exciting current of the larger. Naturally this ideally perfect condition cannot even be approached in practice.

However, it is only reasonable to assume that a very material improvement can be made in regulation and that such improvement, when applied to the voltage-candlepower curve of the incandescent lamp, will be worth considering. It also is appreciated that the power factor of the load has a very important effect on the regulation of a transformer and that this effect is much greater between unity and 95 per cent power factor than in the entire range between 95 per cent and 60 per cent. These points are all being considered in the study of the problem now in progress.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

Purchasing and Stores Section[1]

THE Purchasing and Stores Section for the year 1928-1929 was organized immediately after the close of the 1928 convention at Pasadena. The first meeting was held at Los Angeles, Aug. 16-17, 1928, at which time the organization was completed and the subjects assigned for the year's work. The second meeting was held at San Francisco, Nov. 22-23, 1928, and papers for discussion by the section members were presented by the chairmen of the several committees. The third and final meeting was held at Los Angeles, Feb. 14-15, 1929, at which meeting papers for publication in the section report were presented in the final form.

All meetings were very well attended, and it is hoped that the members found the exchange of ideas in discussions, and the contacts formed with the other company representatives, very beneficial. A feature of the year's work was the display of charts showing the results of material control in reducing the investment in materials and supplies. At the final meeting of the section S. E. Hickman, assistant purchasing agent, San Joaquin Light & Power Corporation, was elected chairman, and William deWaard, storekeeper, San Diego Consolidated Gas & Electric Company, was elected vice-chairman of the Purchasing and Stores Section for 1929-1930.

[1] Executive committee—William Maddock, chairman. S. E. Hickman, vice-chairman. M. A. McMillan, secretary. J. H. Hunt, C. A. Kelley, D. P. Mason, W. J. McCullough, F. W. Smith, C. D. Weiss. **Coast Counties Gas & Electric Company:** M. F. Wales. **Central Arizona Light & Power Company:** C. A. Hulse. **Flagstaff Electric Company:** I. F. Veasey. **Detrick-Joslyn Company:** H. S. Detrick. **Graybar Electric Company:** H. T. Simmons. **Great Western Power Company of California:** F. R. Sherwood. **Illinois Electric Company:** D. C. Pence. **Los Angeles Gas & Electric Corporation:** J. C. Ingle, J. L. LaSpada, L. A. Reed. **Maydwell & Hartzell:** E. C. Condon. **Ohio Brass Company:** R. F. Gheen. **Pacific Gas and Electric Company:** A. A. Charonnat, F. P. Mason. **San Joaquin Light & Power Corporation:** C. H. Grummett. **Southern California Edison Company:** C. P. Altland, J. L. Gray, C. B. Hamilton, F. F. Henry, H. O. McKee, W. J. McCullough, E. F. Meyers, Frank Palmer, W. I. Priest, G. M. Richardson, Joseph Stanton. **San Diego Consolidated Gas & Electric Company:** R. V. Dodge, Jr., William deWaard. **The Southern Sierras Power Company:** C. B. Lore, E. P. Pennebaker, J. S. Scott. **Vallejo Electric Light & Power Company:** Albert Caster.

Purchasing Department Organization

By J. H. HUNT*

THE PRINCIPAL function of the purchasing department is to buy, under any and all conditions, as cheaply as possible the quality of materials required with as little delay as is necessary to handle the orders properly; to see that such orders are properly filled and invoiced; to check all prices and to keep proper record of purchases for future reference, not only for that department, but for other departments of the company. All of this necessitates a certain amount of organization and system.

It is difficult to formulate any set rules to be followed to accomplish this or organize a department to do it, as the amount of organization is dependent upon the volume of business handled. For example, a company spending $1,000,000 per annum would not require the same organization as one spending that much monthly.

* Report of subcommittee of Purchasing and Stores Section. J. H. Hunt, chairman. C. A. Kelley, D. P. Mason, Frank Sherwood.

It all depends upon the size of the concern and the amount and character of business done.

Another factor in organization is the method of "buying" employed. Some concerns (principally the smaller ones) consider it necessary to obtain bids on all orders, no matter how small, but sometimes the delay and effort offsets any possible profit that might be gained in the price. Larger concerns that maintain warehouses can eliminate a lot of such detail by quantity purchases of standard materials from reputable firms at certain established prices which are revised from time to time according to market conditions; also by contracts over definite periods for certain standard commodities, while it is expedient to get bids on others.

The size and amount of organization is contingent upon the system employed. The well organized purchasing department should consist of a purchasing agent, his secretary, a chief clerk, a chief assistant, as many other assistant buyers as the size of the business warrants (each to specialize in the line or lines he handles), as many price clerks and invoice clerks as are necessary to check invoices properly and keep up-to-date purchase records and price cards, and such stenographers, file and mailing clerks as may be required.

Duties

The purchasing agent should supervise the activities of all branches of his departments and prescribe set duties to his assistants, and should see to it that the responsibilities of each are clearly understood and that all clerks know to whom they are to report. He should see that there is no duplication of effort in the department, making each member feel that he or she is an important cog in the machinery thereof, and should any mistakes occur that they be rectified by the responsible party.

The purchasing agent should hold frequent conferences with his assistants and discuss with them all problems and difficulties of the department and invite their suggestions.

The chief assistant should have authority to act for the purchasing agent at all times during his absence, and also should have certain lines of purchasing to do.

The chief clerk should have charge of all clerks in the department, supervise the handling of orders and invoices, and see to it that the price cards, purchase records and files are kept up to date.

In one utility organization there is one assistant purchasing agent who handles all contracts and specifications, sends out the "requests for bids," keeps the files of contracts and specifications, and works in close touch with the engineers. He requires his own secretary, a stenographer and file clerk to assist him. In some other organizations these details are handled by a purchase engineer.

Stores Department Operating Costs

By WILLIAM de WAARD*

CONSIDERING the great variety of materials carried in stock by a public utility company and the difference in the cost of purchasing, receiving, storing and distributing of each particular item, it is impracticable to add to the invoice price of each commodity the exact expense of handling that item.

Pro-Rating of Supply Expense

The Railroad Commission of the State of California, in its instructions for uniform classification of accounts for electric corporations, effective January 1, 1913, made the following ruling:

> "Charge to the supply expense, clearing account, or to appropriate sub-accounts all expenses (except insurance and taxes) incurred directly in connection with the purchase, storage, handling, and distribution of materials and supplies and stationery. It includes the pay and expense of purchasing agents, managers of stores, clerks, and laborers; rents of stores, cost of lighting, heating and undistributed freight and express charges, and the estimated depreciation on supplies due to breakage, leakage, shortage, and wear and tear. This account should be cleared by adding to the cost of materials and supplies passing through stores a suitable loading charge which will equitably distribute the total cost of conducting the stores, and by adding to the cost of such supplies as are bought by the purchasing department pro rate share of the total expense of the purchasing department."

The systems developed to pro rate such expense and to establish the unit cost of the commodities purchased are:

(A)—By adding to the net cost of the material purchased (invoice value less discount), a predetermined percentage, which practice has proven to be sufficient to cover the cost of operating expense of the purchasing and stores department. To this sum is added the freight and drayage charges, which amount is posted on the stock ledger, or stock cards, as the cost of the commodity. (In some cases, the freight and drayage charges are first added to the net cost of the material and then the supply expense percentage is added thereto.)

(B)—The material is placed in stock at the net cost (invoice value less discount) plus freight and drayage expense, and when material is disbursed the supply expense percentage is added.

Comparison

Method "A" has the following advantages:

(1)—The unit price of the commodity is arrived at upon receipt of the invoice, freight and drayage bills, and can be entered on the stock ledger, or stock card.

(2)—The material and supply account balance reflects a true cost of the material, because the expenses of ordering, purchasing, receiving and storing, are included therein. Cognizance must be taken of the fact that the companies are allowed certain earnings on the investment in material and supplies, and it is obvious that such earnings will be slightly larger if the supply expense loading charge is included in the material and supply account balance.

(3)—There is less clerical work involved than in Method "B", because no additions have to be made to the separate disbursement items.

Disadvantage

The disadvantage of this method, however, is that the stores department cannot add any supply expense to the cost of material retired from service, when such material is again placed in stock for reissue later on, because this retired material is returned to stock at the average unit price which already includes the supply expense percentage, added when the material was originally purchased. This is quite an item, particularly when a great deal of reconstruction work is being done, as the amount of material retired from service and returned to stock then reaches as high as from 15 to 20 per cent of the net material turnover (disbursements less material returned to stock).

This, of course, is not the case in method "B", as the stores department is allowed to add the supply expense percentage to retired material returned to stock when it is again issued, because the average unit price then does not include supply expense.

Control of Supply Expense

It is obvious that the storekeeper should have a detailed segregation of the supply expense account prop-

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* Report of stores department organization committee, Purchasing and Stores Section. William de Waard, chairman. C. A. Kelley, William Maddock, D. P. Mason, Joseph Stanton.

erly to control stores operating costs. The following segregation of stores department operating expense is recommended:

1. Superintendence (Salaries and expenses)
2. Store Accounting
3. Storekeeping (Receiving, storing, disbursing)
4. District Storekeepers
5. Yard Labor
6. Watchmen
7. Messengers
8. Stationery
9. Transportation
10. Lavatory expense
11. Repairs to Stores Equipment
12. Power and light
13. Breakage
14. Rent and leases
15. Material scrapped

Monthly comparative statements of the segregated costs will prove to be of great assistance in controlling stores department expenses.

Recommendations

The following factors are most important to secure economy in operation of a stores department.

(First)—Adequate storage facilities in order that all material may be protected from theft and loss, sufficient warehouse space to allow for storage of material which must be protected against climatic and atmospheric conditions, and proper arrangement of bins, shelves and racks to secure both economy of space and ease of access.

(Second)—Efficient equipment and adequate material handling devices for economical transportation and labor costs in the receiving and distribution of material.

(Third)—A simplified, but thorough material control system which will make possible the procurement and storage of the requisite quantity and quality of material at the lowest cost with the least amount of capital invested.

(Fourth)—Standardization and simplification of stores stock which will reduce the number of items to be carried on hand. Also, less storage space will be required and the cost of ordering, purchasing, receiving, inspecting, testing, disbursing and accounting will be reduced.

(Fifth)—A well paid organization, the personnel of which is honest, industrious and accurate, and who realize that they are the custodians of thousands of "material dollars."

Study of Costs

It is recommended further that the members of this section continue the study of "stores department operating costs" at future meetings. Although there are a number of variables in operating conditions of the member companies, there is a sufficient basic similarity in the methods employed to warrant a comparative study of costs, and which can be of continued mutual benefit.

The comparative operating costs can be outlined as follows:

(1)—Computations to be based upon a unit of $100,000 of material purchased for the material and supply account. Large construction items, such as turbines, automotive equipment, cranes, generators, etc., not to be included.

(2)—The stores and purchasing expenses to be expressed in that portion of the total supply expense necessary for each $100,000 purchased. For instance, if the average amount purchased per month (over a period of 12 months) is $500,000, and the average supply expense cost per month is $18,000, then the operating cost per unit of $100,000 purchased, would be $3,600.

It is suggested that the segregated operating expenses be expressed in percentage of the total supply expense. For example: if the average total supply expense per month is $18,000 and the cost of purchasing is $4,500 then the purchasing cost would be expressed as 25 per cent.

Handling Commercial Appliances

By WILLIAM de WAARD*

DURING recent years investments of public utility companies in electrical appliances have increased materially, due to the expansion of the activities of their merchandising departments.

In the solution of the problem of how to handle this part of the business profitably, the stores department can be of great assistance as it is trained in the storing, distributing and accounting of material.

The following are the most pertinent factors with which the stores department has to deal in the handling of appliances:

1.—The accounting of appliances.
2.—Receiving, storing and distribution.
3.—Deliveries to customers.
4.—Inventories.
5.—Damage through delivery, or demonstration.
6.—Surplus and obsolete appliances.
7.—Billing methods.

Accounting System

It is necessary that a separate set of accounts be established for the operation of the merchandising department in order that the merchandising manager may know the exact costs of conducting the appliance business.

A sample of the accounts as now used by one of the public utility companies on the Pacific Coast accompanies this report.

It does not seem necessary to establish a separate sub-account of stores department operating costs to segregate the expenses involved in the handling of appliances in the stores department. Also a reduction in the usual loading charge for supply expense does not seem warranted considering the special care that must be taken in the handling of electrical merchandise on account of its fragility and susceptibility to damage. However, in the case of large and expensive electrical installations where appliances are delivered direct by the vendors to the point of destination, a reduction in the supply expense rate seems advisable to enable the merchandising department to show greater profit or to meet competition of fuel oil or gas installations.

In either case the loading charge must cover all expense of ordering, purchasing, receiving, inspecting, storing, disbursing, stores accounting and the maintaining of a perpetual inventory system.

Receiving, Storing and Distribution

Upon receipt, the appliances should be carefully inspected for damage or missing parts to avoid delay in making claims and to procure replacement parts. The defective appliances should be kept separate and by attaching a special "defective appliance" tag, the possibility of shipping the defective merchandise to fill orders is minimized.

Minor repairs can be made by the storeroom employees, but it is suggested that all the major repairs be made by the appliance department servicemen who are

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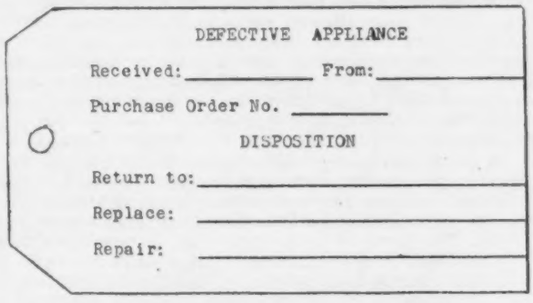
* Report of stores department organization committee, Purchasing and Stores Section. William de Waard, chairman. G. H. Grummett, C. A. Hulze, William Maddock, C. B. Hamilton.

more experienced in this work. The cost of major repairs should be charged back to the vendors.

Storing and Distribution

A separate section or, where possible, a separate storeroom should be maintained for the storage of appliances. This storeroom should have adequate storage space to accommodate refrigerators, ranges, washing


DEFECTIVE APPLIANCE

Received:_____ From:_____

Purchase Order No. _____

DISPOSITION

Return to:_____

Replace: _____

Repair: _____

Fig. 1. A typical "defective appliance tag."

machines, ironers and other heavy merchandise and there should be sufficient shelving for the storage of the smaller appliances and parts.

An alphabetical arrangement of the stock and the subdivision of the appliances into major groups will simplify the handling and storing, and by similarly arranging the stock cards the accounting and inventory work may be done economically. The following divisions of appliance stock are recommended:

1.—Ranges and water heaters.
2.—Refrigerators.
3.—Washing machines and ironers.
4.—Air heaters.
5.—Other appliances.
6.—Supply and repair parts.

In the larger companies it may be advantageous to concentrate stocks of the heavier appliances at one or more central points to take care of the needs of the several districts. Distribution from these points to the customer will not only speed up delivery, but will lessen the handling cost considerably.

Deliveries to Customers

Orders for delivery of merchandise should originate in the sales department and there care must be taken that detailed information is shown as to description of appliance sold, point of destination and date of delivery. The stores department should do everything in its power to have the appliances delivered to customers on the date promised, in order to retain their good will.

The use of light pneumatic-tired speed trucks especially equipped with straps, padding, skids, etc., will protect the merchandise enroute. In the delivery of heavier appliances it may be found advantageous to have the truck driver and serviceman work together so that the appliance may be installed, adjusted and put in presentable condition before the employees leave the customer's premises. Such men should be selected especially for appearance, courtesy to customers and knowledge of their duties.

Inventories

Electrical appliances on the average are more costly per unit than the ordinary stores stock and require closer attention on the part of storekeepers. Therefore, the annual physical inventory should be supplemented by periodical inventories throughout the year.

Care must be taken that no appliances, or parts, are issued without authority of the sales department, or upon request of district storerooms. A perpetual inventory stock card, or stock ledger system will minimize loss.

Damaged Surplus and Obsolete Appliances

Appliances that become damaged or shopworn through demonstration or display, if beyond repair or unsaleable at a reduced price, should be charged to the demonstrating, canvassing and new business account. The appliances damaged through delivery, should be charged to transportation.

Some of the electrical merchandise carried in stock becomes obsolete by reason of the constant improvements in electrical appliances by the manufacturers. It therefore is advisable that only standard, reputable appliances be purchased and these in limited quantity.

Occasionally the companies have a surplus of some particular appliance due to the merchandise not being generally accepted, through overbuying for campaigns or due to the fact that the appliance is in its experimental stage. The best methods of disposing of such stocks are:

1.—Through cut-price sales.
2.—By having a sales campaign.
3.—Distributing as premiums with the sale of larger appliances, such as ranges, refrigerators, and washing machines.
4.—By using such stock as a "leader" to influence the sale of a much-wanted or desirable appliance.

No doubt the most common method for the disposition of material of this nature is through price reduction or by giving it as a premium on purchases over a stipulated amount.

Billing Methods

Since the stores department carries in stock all supply parts the billings for such parts originate there. It is advisable, however, to allow the repairmen to carry a sufficient supply of the most commonly used repair parts on their trucks. Such parts should remain as stores stock until accounted for by the repairmen through the use of a field report which should cover in detail all parts drawn or returned to the storeroom as well as those used for repairs. The billing to the customer for the repair parts used is also done by the stores department and then forwarded to the commercial department, for their approval and the addition of the labor charge.

Conclusion

There should be complete co-operation between the stores, purchasing, and merchandising departments, if this phase of the utility business is to be profitable.

The representative of the stores department should be present at all meetings, interdepartmental or otherwise, that have to do with forthcoming plans of campaigns or special sales. In this way the stores department will be able to contemplate a plan for ordering the appliances and arrange for their distribution to the district stores in time for the opening of the campaigns.

Everything possible should be done to keep the appliance stock moving. Slow-moving or obsolete appliances should be constantly called to the attention of the merchandising manager, for some method of disposal. A weekly or periodical stock sheet showing the appliances in stock that are readily available will keep the districts and sales supervisors posted at all times and perhaps bring to their attention some slow-moving item which they may have a particular sale for, thus helping to move slow-moving material.

By the keeping of records and charts of the appliance sales and the cost of operation, a complete picture may be provided showing past experience and affording an abundance of information on which to base future operations.

Classification of Accounts — Merchandise Department Operating Revenue Accounts Effective January 1, 1929

M 1001—Merchandise Cash Sales—This account shall include all revenues derived from the sale of merchandise for which cash was paid on the date of sale.

M 1002—Merchandise Charge Sales—This account shall include all revenues derived from the sale of merchandise which will be due for payment within thirty days from date of sale.

M 1003—Merchandise Contract Sales—This account shall include all revenues derived from the sale of merchandise which is made in accordance with specified contract terms, or lease agreements, payment for which is to be made in monthly installments, as specified in the terms of the contract or lease agreement, over a period of time in excess of thirty days from date of sale. (Note) The amount added to the selling price of merchandise as a carrying charge shall be included in this account.

M 1004—Merchandise Miscellaneous Sales—This account shall include all revenues derived from the sale of merchandise which is not included in any of the foregoing accounts.

M 1005 — Merchandise Return Sales — This account shall include the amounts credited to customers for merchandise returned to accounting company for nonpayment, dissatisfaction or defective material. (Note) The price at which merchandise was returned to stock will be credited account 1102—"merchandise returned to stores."

M 1006—Merchandise Sales Allowances—This account shall include the amount allowed customers for appliances accepted by the company in part payment on the sale of merchandise by the accounting company.

M 1007.1—Employee Discounts—This account shall include the amount of discounts allowed employees of the accounting company for the purchase of merchandise. (Note) Sales to employees shall be credited to the appropriate operating revenue account in accordance with the class of sale and at the full list or selling price of the merchandise sold.

M 1007.2—Customer Discounts — This account shall include the amount of discounts allowed to purchasers other than employees of the accounting company for the purchase of merchandise .(Note) Sales made to purchasers other than employees of the accounting company coming under this account shall be credited to the appropriate operating revenue account in accordance with the class of sale and at the full list or selling price of the merchandise sold.

M 1008—Job Orders Billed — This account shall include all revenue derived from jobbing and contract work such as house wiring and piping and similar work originating in and coming under the supervision and operation of the merchandise department. (Note) Revenues derived from the installation or repairing of any appliance shall not be included in this account. (Note) Revenues derived from any jobbing work or contracting originating and coming under the supervision of other departments shall be considered as miscellaneous revenue under the appropriate department.

M 1009—Installations Billed—This account shall include all revenue derived from the installation of appliances for which the accounting company is entitled to compensation.

M 1010—Repairs Billed—This account shall include all revenue derived from repairing appliances for which the accounting company is entitled to compensation.

Operating Expense Accounts

M 1101—Cost of Merchandise Sold — This account shall include the cost of all merchandise sold, including freight, express, cartage and expenses incurred in the delivery of merchandise from vendor to stores department or sales rooms. Also the expense in connection with the purchasing, warehousing and handling of merchandise. This account will also include the cost of merchandise and repair parts furnished gratis to customers in replacement of prior purchases which have proved defective. All amounts allowed by the manufacturer for defective merchandise which has been replaced to the customer gratis by the company should be credited to this account.

M 1102—Merchandise Returned to Stores—This account shall include the value of all merchandise returned to stores which had been previously charged to customers or had been allowed value in the purchase of new merchandise. (Note) The minimum depreciation on merchandise returned to stores shall be determined as follows: 25 per cent of the original cost of the article returned shall be deducted for the first month the article was in the customer's possession and five per cent additional for each succeeding month thereafter.

M 1103—Inventory Adjustment—This account shall include the amount of monthly accruals computed upon the basis of one per cent of the net gross sales each month as a reserve for inventory shrinkage and adjustment. The amount so accrued shall be credited to an appropriate reserve. (Note) All entries charged or credited against the reserve for differences between inventories and stock records must bear the approval of the accounting executive. Losses of major appliances from the display or sales stock should be thoroughly investigated before charging against the reserve. The amount by which merchandise has depreciated in value through age, obsolescence or market conditions as determined by the storekeeper and merchandise manager shall be charged to the reserve account.

M 1104—Labor and Material Installing Merchandise—This account shall include all labor, material, transportation and other expenses incurred in the installation of appliances which are sold "installed" and for which company is to receive no additional compensation. (Note) This account shall not include any expense incurred in installation of appliances for which the company is entitled to compensation. The cost of such installation shall be charged to account No. 1202, "cost of installation."

M 1107—Quantity Discount—This account shall include the amounts of quantity discounts allowed by manufacturers, dealers, etc., for purchase of merchandise and jobbing materials during the current year.

M 1201—Cost of Job Order Work—This account shall include all labor, materials, transportation and other expenses incurred in job—such as house wiring, piping, installation of lighting fixtures, repairing and other similar work for which the accounting company is entitled to receive compensation. (Note) The account includes expenses arising only from such jobs as originate with and come under the supervision of operation penses incurred in job—such as house wiring, nate with and come under the supervision or operation of the merchandise department. (Note) This account shall not include the cost of installing merchandise or repairing appliances. Expenses of this nature for which the accounting company is entitled to receive compensation shall be included in account No. 1202, "cost of installation" or account No. 1203, "cost of repairs."

M 1202—Cost of Installation—This account shall include all labor, materials, transportation and other expenses incurred in the installation of appliances for which the accounting company is entitled to receive compensation. (Note) This account shall not include any expenses incurred in installing appliances sold "installed"; such expenses shall be included in account No. 1104, "labor and material installing merchandise."

M 1203—Cost of Repairs—This account shall include all labor, materials, transportation and other expenses incurred in repairing or servicing merchandise for which the accounting company is entitled to compensation. (Note) This account shall not include any expenses incurred in repairing and servicing appliances for which the accounting company is not to receive compensation.

Such expenses shall be charged to the utilization account —consumers' installations.

M 1301.1—Superintendence — This account shall include the salaries, commissions and bonuses paid the manager of the merchandise department, his assistants, clerks and stenographers employed in a supervisory capacity. (Note) In the case of the merchandise department being operated as a part of the general sales department this account shall include a proportionate part of the salaries of the general sales manager, his assistants and clerks for supervision and assistance rendered the merchandise department.

M 1301.2—Superintendence Supplies and Expenses—This account shall include the traveling and incidental expense directly applicable to the management and supervision of the merchandise department. The expense of operating and maintenance, including depreciation, of automobiles assigned to the manager of this department shall be included in this account.

M 1302.1—Salaries of Salesmen—This account shall include the salaries of store managers, chief salesmen and salesmen when specifically engaged in the sale of merchandise.

M 1302.2—Commission of Salesmen — This account shall include commission paid to salesmen for the sale of merchandise. Commissions paid to employees of other departments for stimulating sales of merchandise shall be included in this account. (Note) Commissions paid to salesmen shall be computed on the cash selling price of merchandise and should not, in any case, be computed on the basis of installment sales price.(Note) The amount paid employees of other departments as "tip" commissions shall be deducted from the amount of commission paid to salesmen credited with the sale of such merchandise.

M 1302.3—Bonuses—This account shall include the amount paid as bonuses to stimulate the sale of specific types of merchandise, generally referred to as "load builders."

M 1303—Expenses of Salesmen—This account shall include the traveling and incidental expenses of salesmen incurred in connection with the sale of merchandise.

M 1304—Demonstration—This account shall include all labor and miscellaneous supplies such as soap, washing powder, flour, coffee, etc., which are required in the actual demonstration of general merchandise for sale. (Note) Demonstrations, educational campaigns and home service work intended to stimulate the use of electricity or gas in appliances already sold shall not be included in this account but shall be charged to the appropriate sub-account under "new business expense." (Note) Expenses in connection with the initial demonstration of a new appliance in a community shall not be included in this account, but shall be charged to the appropriate sub-account under "new business expense." New appliances as referred to in this account shall be interpreted as follows: Any type of appliance which has not been offered for sale generally throughout the industry or in the particular community in which it is being introduced, or one that through radical changes in design or construction may be considered as a new idea. Before charges hereunder may be made to the appropriate new business account approval must be secured in advance from the accounting executive. Changing brands of appliances shall not come under this provision.

M 1305 — Premium on Merchandise Sold — This account shall include the cost of all premiums donated to customers on the purchase of merchandise.

M 1306—Sales School Salaries and Expenses—This account shall include the salaries and expenses incurred in connection with instruction of salesmen. (Note) Expenses incurred in connection with instructions of service men in repairing and servicing appliances shall not be included in this account but shall be charged to the utilization account—consumer's installations.

M 1307—Delivery Expense—This account shall include all labor, and expenses, including depreciation, of automobiles, wagons and other vehicles employed in the delivery of merchandise from sales rooms or stores department to the premises of the customers, also the cost of messenger service, postage, prepaid express, etc., on delivered sales. (Note) The cost of delivering merchandise from freight or express depots shall not be included in this account, but added to the cost of merchandise. (Note) The cost of delivering merchandise from the stores department to the salesroom shall not be included in this account, for such expenses shall be included in the percentage added to the cost of merchandise for purchasing, warehousing and handling.

M 1308.1—Advertising Salaries and Expenses—This account shall include the salaries and miscellaneous expense incurred in connection with advertising applicable to the merchandise department, also that proportion of the salaries and expenses of the general advertising department as is directly concerned with merchandise department. Fees paid to advertising agencies shall also be included in this account.

M 1308.2 — Newspaper Advertising — This account shall include the cost of all advertising space used in newspapers, magazines, periodicals, and other publications for advertising merchandise.

M 1308.3—Billboard Advertising—This account shall include all charges for painted billboards, pasted or hung posters, advertising merchandise.

M 1308.4—Direct-by-Mail Advertising—This account shall include all charges for direct-by-mail advertising merchandise.

M 1308.5 — Window Display Advertising — This account shall include all charges for window display, advertising merchandise, also cost of incidental trimming, changing and upkeep of the show windows and display cases.

M 1308.6—Miscellaneous Advertising — This account shall include all charges for merchandise advertising not chargeable to any of the foregoing advertising accounts.

M 1309—Miscellaneous Sales Supplies and Expenses —This account shall include all miscellaneous sales supplies and expenses not chargeable to any of the foregoing sales accounts. (Note) Labor, materials and other expenses incurred in repairing or improving display fixtures, painting, wiring and rewiring and piping for the display and demonstration of merchandise in the salesrooms and stores shall be included in this account. Premiums given to salesmen in connection with sales campaigns shall also be included in this account.

M 1401.1 — Commercial Accounting — This account shall include that portion of the cost of labor of superintendents and assistants, bookkeepers, cashiers and assistants, chief clerks, general clerks, collectors, switchboard operators, messengers, janitors and watchmen emcollecting of merchandise accounts. (Note.) This account shall not include the cost of office supplies, stationery, telegrams, telephone service, etc., incidental to the recording and collecting of merchandise accounts.

M 1401.2—General Office Salaries—This account shall include that portion of the salaries of auditors, bookkeepers, cashiers, paymasters, clerks, janitors, porters, messengers and other employees whose time is devoted to general accounting applicable to the merchandise department.

M 1402.1—Commercial Supplies and Expense—This account shall include the cost of office supplies, stationery, telegrams, telephone service, postage, etc., incidental to the recording and collecting of merchandise accounts.

M 1402.2 — Printing and Stationery — This account shall include the cost of all printing, forms, paper, postage and miscellaneous office supplies actually used by the merchandise department. (Note) No portion of the ordinary or special expense of the utility for printing and stationery shall be included in this account. (Note)

Commercial supplies and expenses incidental to the recording and collecting of merchandise accounts shall not be included in this account but shall be charged to account No. 1402.1, "commercial supplies and expenses."

M 1402.3 — Telephone and Telegraph — This account shall include the rentals for telephone stations installed for special use of the merchandise department, also all toll charges and telegraphic messages originated or accepted by the merchandise department. (Note) No portion of the ordinary or special expense of the utility for telephone and telegraph expense shall be included in this account.

M 1403 — Legal Expenses — This account shall be charged with the proportionate part of the general legal expense applicable to the merchandise department, this amount to be determined only and authorized by the accounting executive. The cost of recording sales contracts and repossessing merchandise sold shall also be charged to this account.

M 1404 — Insurance — This account shall be charged with the premiums paid for fire, burglar, lightning, tornado, and other insurance applicable directly to the merchandise department. (Note) No portion of the ordinary or general insurance of the utility shall be allocated to the merchandise department other than the insurance carried on the stock of merchandise which shall be allocated on the ratio of the value of the merchandise stock to the total material and supplies account covered by a blanket or general policy.

M 1405—Other Miscellaneous General Expense—This account shall include the cost of miscellaneous supplies and expenses of a general nature not otherwise provided for, viz: repairs and imporvements to equipment, expense of office renovation, rental of office equipment, expenses of operation of company owned buildings, also the traveling and incidental expenses of auditors, clerks, etc., directly chargeable to the merchandise department. (Note) That portion of the expense of operation and maintenance of company owned buildings shall be allocated to the department on the basis of floor space occupied by the department in proportion to the entire floor space of the building. (Note) No portion of the ordinary or special expenses of the utility other than directly applicable to the merchandise department shall be included in the account.

M 1406—Rentals—This account shall include the proportionate amount of rentals paid and expenses incurred for building or space used for the purpose of merchandising. (Note) Charges for rentals shall be made in ratio of the floor space used by the merchandising department to the total floor space of the leased or rented building. (Note) Rentals for storerooms or warehouses shall not be charged to this account, but shall be included in the purchasing and warehousing clearing account and added to the cost of merchandise.

M 1407 — Taxes — This account shall include the amount of taxes which can be directly allocated to the merchandise department. (Note) In such cases when real and personal property taxes cannot be directly allocated to the department the proportionate part of the real and personal taxes assessed in the city or town in which the department is located shall be allocated on the valuation of the assessable property of the department to the valuation returned by the utility as a whole in the city or town. Federal income tax shall be allocated in the same manner as in the electric and gas departments.

M 1408—Uncollectible Accounts—This account shall include the monthly accrual based on a percentage of the monthly net gross sales, determined by the accounting executive as being sufficient to cover merchandise accounts, which after diligent effort has been made for their collection, have been deemed worthless. (Note) The amount so accrued shall be credited to the appropriate reserve account.

M 1500—General Interest—This account shall include the amount of interest charged to the merchandise department. (Note) Interest shall be computed monthly at the rate of six per cent per annum on the amount invested at the end of the preceding month in accounts receivable, merchandise stocks and furniture and fixtures.

Handling Empty Containers

By WILLIAM de WAARD*

THIS committee recommends the following system of handling empty containers, which will prorate the expense properly to operating and construction accounts, and give a permanent record of all transactions necessary to store, distribute and account for containers.

Identification

When material is received in returnable containers the containers should be marked with the purchase order number on which they are received. The use of embossed brass tags has been found very satisfactory for marking carboys, drums and reels. The reports of the receiving department should specify the manufacturer's serial number and identification marks of the containers when the material is received.

Containers which have been purchased outright by the company, or which have become their property due to being non-returnable should be identified properly as the company's property. In some cases it has been found advisable to paint such containers with the company's standard color paint, or to mark them with brass property tags so that they will not be confused with returnable containers.

Records

It is recommended that the records of returnable containers be the same as those of all other material charged to the material and supply account. Furthermore, it is important that such records show serial number, purchase order number, name of the firm from which received, date of receipt and the location of the container. A similar record also should be kept of containers which are the property of the company, only such record would not show money balance.

Disbursing

The transfer of containers from one store to another, or to jobs, should be handled in the same manner as other material, for they represent money invested as well as does the material itself. Should the container belong to the company, the disbursement sheet should be marked accordingly and the charge against the job should be marked "memo." However, all charges and credits for the containers, either returnable or non-returnable, should be routed through the stock card clerks in order that they may make the proper postings and record the disbursement or receipt of such containers.

It may be seen that if the containers are not returned after the completion of the work, no credit will be sent through and the loss of the container

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*Report of stores department organization committee, Purchasing and Stores Section. William de Waard, chairman. A. A. Charonnat, G. H. Grummett, Joseph Stanton.

would remain charged against that particlar job. If the container, when returned, should be broken and of no further value the credit to the job is marked accordingly and the cost of the container is charged to the job.

Accounting

Properly to account for the expense of handling returnable containers it is recommended that a "suspense account" be set up as a subdivision of the material and supply account. Upon receipt of the invoice 80 per cent of the invoice value of the container should be charged to the M. & S. account and entered on the stock ledger or stock card record as the value of the container. The balance of 20 per cent should be charged to and included in the price of the commodity in the container.

When the containers are returned to the vendor, or otherwise disposed of, the stock card value (80 per cent of the original invoice value) should be transferred to the "suspense account." All expense incurred in the handling of containers, such as drayage, freight, repairs, etc., also should be charged to this account. This "suspense account" then is credited with the full amount of credit received from the vendor.

Actual practice proves that 20 per cent of the original invoice value of the container is adequate to cover all expenses and to leave a sufficient credit allowance to absorb the loss of lagging, breakage and other losses sustained.

In this method of accounting, the expense of handling containers properly is charged to the commodity received in the container and a true unit cost of the material is arrived at.

Return of the Containers

When the containers are empty and ready to be returned a list showing the serial number and the names of the firms to which they belong should be forwarded to the person keeping the container records. The record cards should be referred to for checking purposes. It is advisable to obtain shipping instructions from the vendors before returning empty containers, as it often saves unnecessary freight charges because in some cases it has been found that the vendor wanted containers returned through another shipping point in order to accumulate a carload shipment.

Records regarding the return of empty containers should be the same as those covering the return of standard material with the exception of the credit allowance which should be handled as stated under subdivision "accounting." When empty containers are returned over the same route as received when full, the bill of lading should be so marked in order that the shipper may take advantage of lower freight rates. When returning cement sacks, they should first be passed through the sack shaker so that as much cement as possible may be saved. A certain class of empty container, such as tin cans and wooden barrels can be used in the stores department, for shipping other material or may be sold to florists and junk dealers. Oxygen and acetylene tanks should be tested before being returned, to be sure they are empty. A pressure gauge is used for testing and it is surprising to find the amount left in some of the tanks.

Inventories

It is recommended that a monthly inventory report be made of all containers in each district. This report should be forwarded to the clerk handling container records, for checking, as such a report will assist materially in maintaining the records up to date and will act as a safeguard against an accumulation of empty containers in outlying districts.

Stores Department Facilities

By G. H. GRUMMETT*

SINCE the paper on this subject written by R. V. Dodge, Jr., and included in the 1926-27 report is very complete, this article deals only with such features as have been developed since that time.

Handling of Scrap Materials

The various companies are emphasizing the value of scrap and salvage materials of all kinds. For that reason it is recommended that adequate facilities be provided for the handling and storing of all scrap materials which have a salvage value.

The practice of one company in collecting and handling scrap copper has proved very satisfactory. All scrap and retrieved wire is collected in metal bins as it comes to hand. Periodically this material is taken to a central point and the insulation is burned off. The remaining copper then is put through a baling machine which turns out a compact and easily handled bundle.

Because of the price differentials of various metals, it is essential that all metallic scrap be segregated.

Salvaging Lead Cable

The problem of salvaging scrap cable and recovering the copper and lead at the least cost per pound has been solved by the apparatus developed by one company. This apparatus consists of a shallow steel pan mounted on an angle-iron framework. Over this pan are placed cast-iron grate bars. A hole is drilled at the lowest point in the pan and a pipe with a cast-iron stop cock is connected thereto.

The cable is thrown onto the grate bars and ignited with a kerosene torch. When it starts to burn there is sufficient heat to melt the lead which flows into the pan. When a sufficient quantity of fluid lead accumulates it is drawn off into pigs through the cast-iron cock. It is necessary to keep this cock hot with the torch to keep the lead flowing.

The pig molds are mounted on a roller platform and are pulled away as they are filled. The platform will hold ten individual molds averaging 50 lb. of lead each. The copper is left on the grate bars and later is pulled off with a rake, cleaned of the insulation by drawing it over the ground, and then baled.

Emergency Materials

All public utilities have line trouble and other emergency work which must be taken care of at unusual hours when the storekeeper is not on duty. It is recommended therefore, that a suitable space be partitioned off for an "emergency material room," in which may be kept materials most likely to be needed for emergency repairs. A key to this room should be given to the district foreman and one to the night watchman. Material used from this emergency stock should be reported to the storekeeper the following day so that the proper charges can be made and the stock replenished.

Replacing Obsolete Materials

In practically all companies, materials and apparatus are being discarded constantly for newer and more improved methods, yet a great many of these items are left installed because they are serving their purposes. For this reason it is recommended that a space be provided for the storing of a small quantity of such items to be available for repairs or probable replacements.

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* Report of stores department facilities committee, Purchasing and Stores Section. G. H. Grummett, chairman. R. V. Dodge, Jr., William Maddock, E. P. Pennebaker.

Materials so cared for are not of necessity in the materials and supplies account, in fact should not be, yet they often will be found of primary importance in an emergency.

Night Loading

Much time may be lost by crews of men waiting in the morning for materials to be issued to them. To avoid this time loss, for which the stores department is responsible, it is recommended that whenever possible material be assembled in the afternoon for the following day's work. The material may be placed on the loading platform in bins or boxes and properly tagged. The loss of time may be reduced further by having a hostler bring the trucks to the platform and load the material at night, or by leaving the trucks backed up to the platform. By extending the covering marquee, sufficient protection from the weather may be secured and additional garage space is created at slight additional cost.

Facilities for Cleaning

For cleaning surfaces of salvaged pipe, valves, etc., preparatory to painting them, a portable sand blasting machine of suitable capacity is the most satisfactory method.

Conclusion

In closing, the committee wishes to emphasize again how helpful it would be to all concerned if a "Handbook of Stores Structures, Furnishings and Handling Devices" were available when plans are being made for improvements.

Inventories and Pricing

By C. B. LORE*

THE company using this system operates over a power system extending from Tioga Pass, Calif., to Yuma, Ariz., and its 45 storerooms are scattered the 600-mile length of this line. Much of its territory is difficult of access at certain periods of the year.

The taking of inventory begins shortly after the first of January and continues until about the first of November. Due to climatic conditions the work is started in the southern part of the system and gradually progresses north into the mountainous districts and by the month of June all storerooms in the mountains are accessible.

It is reported that this method is the outcome of many years trial and has been adjusted from time to time to fit particular needs. The procedure followed for taking inventory is practically as follows:

Procedure

The auditor draws up a tentative schedule for the coming year's inventory, furnishing the stores department with copies. This schedule is discussed and changed when necessary to meet conditions that may arise and have a direct bearing on the program. The dates having been agreed upon, notices of inventory are mailed out by the auditing department so as to reach the storekeepers from fifteen to thirty days in advance of the inventory date. All clerical and physical preparations are to be completed, inventory cards in place and counting done by the dates specified for the taking of inventory.

The traveling auditor upon arrival then checks the stock records and verifies the unit costs and makes the cut-off on storeroom forms and a check count of such items as meet his purpose and then collects inventory cards. These cards bear consecutive numbers and correspond with like numbers shown on stock record cards. They are arranged in order, compared with stock records, and the space at bottom of card for the use of the auditor is filled in.

Discrepancies between inventory cards and stock records then are investigated and a certificate of inventory signed. The inventory cards are forwarded to the general office where inventory lists in triplicate are prepared and distributed, the auditor retaining one copy and one copy each going to the stores department and the storeroom affected.

The following are excerpts from general orders of the company using this system:

"Stock cards shall be balanced when necessary to use the reverse side or when transferring to a new card.

"Stock cards also shall be balanced immediately prior to any inventory of the stock.

"A physical inventory of storeroom stock shall be made at least once a year and at such other times as changes in storekeepers or other conditions may render necessary.

"Inventories shall be taken by the storekeeper under the supervision of a traveling auditor of stores accounts as a representative of the auditor.

"It shall be the duty of the traveling auditor of stores accounts to co-operate with the storekeeper in this work to the end that a complete and accurate inventory may be taken, with the items properly listed and priced.

"He shall check the stock cards to verify the correctness of the unit costs.

"He shall investigate as fully as possible any discrepancies between the inventory and the stock card record.

"Inventories shall be listed in triplicate, priced and extended. When the final totals are agreed upon the inventories shall be signed by the storekeeper and the traveling auditor as the true amount charged against the storeroom and for which the storekeeper is responsible for a proper accounting.

"In cases where there is a change of storekeepers, both the incoming and outgoing storekeeper shall sign the inventory with the traveling auditor.

"The traveling auditor shall see that the inventory figures are properly entered on the stock cards.

Clerical Preparation

"All current work should be brought up to the minute.

"All material issued from or returned to the storeroom must be shown on storeroom forms and entered on stock cards.

"All invoices should be entered up to date for material which has been received.

"After all entries are made on stock card, unit cost should be checked.

"A record should be kept of all material received, and for which an invoice has not been received.

"The purchasing agent should be requested to trace all delayed invoices and a request for manifests due should be made on other storekeepers.

"Stock record files should be checked and all dead cards removed and filed alphabetically in the dead-card file.

"All cards in live file should be arranged in alphabetical order, and where several sizes are shown for the same items, cards should be arranged by sizes also.

"Inventory cards, Form 789, then should be made up from the stock cards showing the same description and unit, care being taken that they are arranged in the same relative order as the stock card.

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* Report of inventories and pricing committee, Purchasing and Stores Section. C. B. Lore, chairman. William Maddock, L. H. Prentiss.

"The inventory cards should be prepared either on the typewriter or with ink and should be numbered consecutively, and the corresponding number should be placed on the record card in pencil.

Physical Preparation

"Shelf stock should be so arranged as to facilitate the work of counting; the small items should be tiered in uniform rows, which will eliminate the work of counting each piece of material.

"Wire should be segregated carefully. Where the original tags are missing the coils should be measured and weighed and tagged and all tags arranged so that they will be in plain view.

"Serially numbered apparatus and equipment should be so arranged that the name and number plate can be easily seen.

"Partly filled containers of oil or other liquid should be tagged and the contents and quantity shown so that it will be necessary at inventory time only to verfy the count.

"All poles should be marked with height nails.

"All scales should be tested and balanced.

"All of the above physical labor should be performed before an attempt is made to make the regular count of material.

Counting

"Inventory cards should be distributed just prior to the time counting is to begin. These cards should be distributed by someone thoroughly familiar with the material and to expedite distribution should be grouped, each group representing a section of the storeroom.

"The cards having been distributed, counting should progress rapidly and should be done by employees who are known to be accurate and who know the material.

"Items received and issued after material has been counted should be entered in spaces provided on inventory cards.

"As the material is counted entry should be made on the inventory card and it should be placed with the material it describes and care should be taken that the cards are made secure.

"One exception to the above paragraph relates to material stored out-of-doors. These cards, when count is filled in, should be collected and placed in a safe and convenient place, preferably a stock card file, until they are used by the auditor in checking count and material.

"All other cards will remain in place with the item they represent until they are collected by the traveling auditor.

"All material received for which no invoice or manifest has been received must be kept separate from other stock. This material is not included in the inventory count.

"When the same material is located in more than one place a notation to this effect should be made on the bin inventory card of the regular stock showing the quantity and location of the surplus stock.

"Stock should be reduced to the lowest point consistent with good service, so as to eliminate unnecessary work in counting.

"Colored chalk or lumber crayons should be used in checking such items as pipe, poles, crossarms, as an indication that each piece has been counted."

Pricing

The company using this method reports that the cost of an article is determined in their general orders, as follows:

"The following items shall be charged to the storeroom account, materials and supplies:

"The net cost of all materials and supplies when purchased. (Cash Discounts for prompt payment not to be considered).

"Transportation charges as hereinafter specified.

"All freight and express charges on materials from the suppliers to point of shipment shall also be charged to materials and supplies account and added to the invoice cost of the items covered.

"At construction storerooms and other storerooms remote from railroad stations, where trucking charges are a large item in the transportation, such expense from station to storeroom also shall be charged to materials and supplies account and added to the cost of the materials. Other items, though not specified under this general order, are taken into consideration when figuring costs such as inspection charges, unloading charges on car lots, painting and peeling of poles and painting of crossarms, these items being handled on shop job orders where labor and supplies are accumulated and then charged direct to the material.

"Distribution of supply expense is handled as provided in 'Uniform System of Accounts for Electrical Corporations' under 'Clearing Accounts,' these accounts being cleared by adding a suitable loading charge to cost of material and supplies passing through storerooms.

Unit Costs

"The cost at which any article is to be charged out of storeroom shall be the average unit cost of the 'balance on hand' of any article listed by size or class on a separate card.

"Upon receipt of the first shipment of any article, the unit cost shall be obtained by dividing the total cost (amount of invoice plus freight or express) by the total quantity of the articles received.

"The unit cost thus obtained will remain the same until an entry is made at a different price from the original.

"A new average unit cost then shall be figured as follows:

"The card first shall be balanced, bringing down the 'balance on hand' in the two columns 'quantity' and 'total cost.'

"To this balance then shall be added the quantity and cost of the newly entered material and the final cost thus obtained shall be divided by the final quantity for a revised average unit cost.

"This calculation shall be made as often as materials are received which vary in price from the stock on hand."

Salvage Segregation and Classification

By W. J. McCULLOUGH*

CASH value of the salvage accumulated by the larger public utility companies amounts to several hundred thousand dollars yearly and the supervision of this work should be in charge of men of unquestioned honesty and integrity. The reasons are obvious and are not set forth in this report.

In reporting on the subject of salvage this committee refers to that class of materials and equipment for which there is no further use. It may be new, second hand, or worn out, and in disposing of it, it may be sold as is or may be reduced to base metal as the agent in charge may direct.

Regarding new material or equipment transferred to salvage, the committee finds that approximately only 1 per cent of the total value is new, about one-third being second-hand and two-thirds worn out. In handling salvage, purchasing and stores representatives should realize two points, (first), to avoid accumulation of

* Report of salvage committee, Purchasing and Stores Section. W. J. McCullough, chairman. C. A. Kelley, G. H. Grummett.

stock that is liable to become obsolete and consequently salvaged by buying in small quantities and (second), to dispose of it quickly at prices obtainable once it is declared obsolete.

Second-hand materials and equipment are accumulated largely due to the completion of large projects, the rebuilding of steam plants, substations, transmission lines, etc., and while in good condition for further use, are recommended for sale by the proper parties, thus becoming what the committee terms "salvage."

Wornout materials and equipment consist largely of copper wire, transformers, meters, switches, hardware of all kinds, which are considered unsafe for further use and must be replaced. This is the largest and most valuable class of material salvaged by the various utilities.

The handling of salvaged materials and equipment is quite different from standard material handled by the stores department inasmuch as it is not known beforehand just what materials are to be received, and the stock on hand must be kept in the process of constant turnover to avoid accumulation. Approximately 75 per cent of this material turnover is made by sales to outside dealers and individuals, the balance being materials reconditioned and placed back in service. This consists of tools and other items of standard equipment for which the cost of reconditioning is justified.

This committee recommends that certain items such as scrap lumber and frame buildings be sold on the job "as is." This saves labor and expense in dismantling and transporting to the salvage department. Any other items of material where it is practical to do so should be handled in a like manner. The accounting of such sales is handled through the salvage department the same as if the material had been returned before sales were made.

All material received by the salvage department should be listed by the district or department shipping the material, each article being tagged showing reference to the original list. This facilitates checking by receiving clerk.

The committee recommends that prices allowed be based upon previous sales of like or similar articles or upon a percentage basis of the original value, the life of the article being considered.

Great care should be taken in consigning items of standard material to salvage department. This causes unnecessary handling as such items are taken into salvage store accounts and then transferred again to general store sections, causing unnecessary bookkeeping and labor in handling.

The committee finds that a great amount of labor and bookkeeping is saved by taking certain kinds of material into account on a weight basis. This may include all items that can be handled without interfering with the proper accounting. For example, pipe fittings are sold by weight and may be taken into account by weight. However, they are arranged on shelves according to sizes and kind so that it is easy for the purchaser to select the sizes wanted.

In connection with the handling of salvage, the committee recommends that the work of reclamation be given close attention, and refers members to the following papers recently prepared by committees of this section:

Obsolete and Scrap Material and Equipment	1924-25
Surplus Materials	1925-26
Surplus Materials	1926-27
Obsolescence and Reclamation	1926-27

The papers listed above refer to activities closely associated with the subject of this report and the present committee finds it difficult to draw a clear line between these various divisions.

As a basis for discussion, the following salvage or scrap segregation is submitted:

Aluminum—Cast	Lead—Battery plates
Aluminum—Wrought	Pipe—3 in. and above
Aluminum—Wrought steel core	Rope—
Brass—Castings	Rubber—Casings, outer
Brass—Turnings	Rubber—Gloves
Copper—Bare	Rubber—Miscellaneous
Copper—Insulated	Rubber—Tires, solid
Copper—L. C. cable	Rubber—Tubes, inner
Copper—Turnings	Steel—Angles, iron, etc.
Iron—Cast	Steel—Turnings
Iron—Mal. insulator tops	Tubes—Boiler
Iron—Wrought	Wire—Iron and cable, bare
Laminations—	Wire—Iron and cable, insulated
Lamps—Butts	Zinc—
Lead—	Zinc—Dross
	Zinc—Skimmings.

Material Standardization—Simplification of Stores Stocks

By G. M. RICHARDSON*

IN THIS report it has been the main endeavor to call attention to materials that are the exceptions to standards, with a view of eliminating such materials from stock.

Pole Line Hardware

A question has arisen as to the best method of reducing inventory investments carried by all concerned, with greater turn-over, better deliveries and a more uniform factory production schedule, resulting in lower operating costs. To arrive at a definite solution it was requested that the sub-chairman of the utilities division secure from the utilities a complete list of all hardware stocked or used in the construction of pole lines.

With all of the foregoing accomplished there should be a great benefit derived in that such information will serve as insurance against the demands of extreme emergencies such as storms, floods, fires, earthquakes, etc., wherein many stocks not only in the hands of the supplier, but the various utilities as well, could be readily available for immediate relief.

The subcommittee chairman has requested a list from eighteen utilities within the P.C.E.A. jurisdiction and to date has received replies from eleven, leaving seven still to be heard from, including two of the major utilities within the State of California. Without complete information from all major companies it will be impossible for this committee to make a final recommendation.

However, sufficient information has been received to indicate beyond a doubt that without necessarily changing the established methods of construction, many items now considered special by the committee could be eliminated and uniform standards adopted. It is found that various utilities are using materials such as angle-braces of slightly different shapes, whereas a uniform standard for similar construction might just as well be employed.

This committee has found that due to the State laws, it will be impossible to adopt N.E.L.A. standards as a whole, and strongly urges and recommends that movement be started at once to establish P.C.E.A. standards for pole-line hardware, incorporating N.E.L.A. standards wherever possible.

It is recommended also that the A.S.T.M. specifications No. A123-28T for hot galvanizing be incorporated in the proposed P.C.E.A. standards.

* Report of materials standardization and simplification committee, Purchasing and Stores Section. G. M. Richardson, chairman; J. L. Gray, vice-chairman. C. B. Altland, E. S. Condon, H. S. Detrick, R. F. Gheen, S. E. Hickman, C. A. Kelley, H. P. Lanyon, William Maddock, D. P. Mason, W. M. McIntosh, E. F. Meyers, A. W. Pride, H. F. Rea, H. T. Simmons, C. H. Thrane.

Insulators

Considerable benefit will accrue to member companies by the simplification of their insulator requirements to the end that their own stocks can be reduced to a minimum and the demand on the supplier can be simplified to the extent that he may have ready for delivery at all times the insulators needed.

Already this work has advanced as may be noted by examination of pamphlet No. R73 of the United States Department of Commerce, entitled "Elimination of Waste, Simplified Practice One-Piece Porcelain Insulators," and by reference to Section 5, "Insulators," of the N.E.L.A. 1927 Overhead Systems Reference Book.

To quote from the Department of Commerce pamphlet:

"It was found upon survey that the rapid growth of the Electrical Industry had led to the development of a large variety of sizes, type, and dimensions of one-piece porcelain insulators. The industry concluded that this condition could be improved and as a first step planned to determine which variety of insulators represented the best thought and practice."

In requesting the co-operative services of the National Committee on Metals Utilization the industry called attention to the prevalent over-diversification of their product and pointed out that in the circumstances it was necessary for the manufacturers to spread production and investment over a wide range of varieties, sizes, and dimensions. The distributors of insulators and of insulator pins were compelled to tie up large amounts of capital in stocks to meet every possible demand when the bulk of normal requirements could be satisfied by fewer varieties.

A preliminary conference was held Nov. 25, 1926, at which the opinion was expressed that the superfluous varieties of insulators could best be determined by a knowledge of the major demands, and it was decided to confine the first survey to one-piece insulators.

On Jan. 20, 1927, the committee held a meeting at which the chairman presented a graphic layout of the various insulators displayed in current catalogs of the manufacturers. Available data served as a basis for designating those insulators in greatest demand as well as those only used here and there.

The first form of recommendation suggested the definite retention of certain insulators as stock items and the elimination of others which were seldom called for. A third classification of those to be discouraged also was made since as the adequacy of the recommended stock becomes more and more firmly established it will be possible to eliminate most, if not all of these appearing in this third classification.

With the survey completed, the committee of the whole requested the Department of Commerce to call a general conference of manufacturers and users to consider the tentative program and put into final form a simplified practice recommendation for the guidance of all interests. On June 3, 1927, such a meeting was held under the joint auspices of the National Committee on Metals Utilization and the division of simplified practice.

Except for a few minor changes the program was approved and the conferees were of the opinion that consistent adherence to the same would result in an annual saving of approximately $400,000. It was stated further that a release of any fraction of the large amount of "frozen" capital formerly tied up in molds alone would be decidedly welcome to everyone. Removing from the shoulders of the manufacturers the burden of making and maintaining a large stock of molds will help greatly to reduce costs all along the line.

The recommendation was made effective from Oct. 31, 1927, subject to annual revision by a standing committee which represented the various elements in the industry. The adoption of this conference report resulted in eliminating about 25 per cent of the variety of one-piece porcelain insulators then manufactured. The conference was attended by practically all of the manufacturers of insulators and has since been adopted by most of them and by a number of the largest users.

Section 5 of the N.E.L.A. Overhead Systems Reference Book gives a general description of insulators with tentative suggestions on one-two-and three-piece pin-type insulators for voltages up to 66 kv. The article also gives suggested test specifications. These suggested insulators are shown with certain tolerances in the different measurements which probably would fit the vast majority of the demands and closely tally with the insulators at present manufactured.

To come to the particular problem in the Pacific Coast Electrical Association this committee believes that the simplification is mostly a matter of co-ordinating the requirements of the several member companies.

To this end the committee undertook to obtain from each member company a list of the insulators which that company considered standard, or a list of insulators that the company was purchasing and using. From these lists it was proposed to make a combined tabulation of all insulators used and ascertain if it were not possible to pick out a composite insulator for each different size which, with allowable tolerance in measurements, not only would meet the demand of all users, but likewise would permit each manufacturer to supply this demand from insulators he now is making and at the same time enable him to cease the manufacture of others.

Apparently but three companies have a standard list of pin-type insulators which does not give this committee sufficient data at this time to make a definite recommendation. However, much good must result from this work as those companies which have not already adopted standards (whether as a result of our inquiries or not) are undertaking an investigation into the insulator situation and are planning to work out a standardization in their several organizations.

This committee believes that the interest aroused in the simplification of stores stocks of insulators will justify continuing the work by this Section during the coming year, (1929-1930). By that time more member companies will have perfected a standard list in their own organizations. Also it is recommended that the committee obtain from each manufacturer a complete list of all pin-type insulators that manufacturer is selling in P.C.E.A. territory.

The lists furnished by the users and by the manufacturers then can be compared and by a process of elimination the numbers and varieties can be reduced to the advantage and satisfaction of all concerned.

The time has been short for the inauguration, and any attempt at completion of the program outlined, but we believe a forward step has been made, and that continuation of the work into next year will be productive of good results.

Manufacturers' Standpoint on Development of Standard Packages

As reported before, after checking this matter with the stores departments of various power companies this committee has received as the opinion of these stores managers that the only two commodities giving them serious difficulty as to variations in packing are porcelain insulators and pole-line hardware. While it possibly may be that the stirring up of this whole subject has accelerated the activities of manufacturers of these two lines toward the adoption of standard packages investigation would indicate they already had nearly reached an agreed packing list.

During a recent visit to Chicago, E. S. Condon, chairman of the manufacturers section of the subcommittee on development of standard packages, found that the two largest Eastern manufacturers of pole-line hardware apparently had agreed upon a packing list submitted to them by the stores manager for the Chicago Commonwealth Edison Company. As far as the Pacific Coast is concerned they undoubtedly will put this list

into practice here and it only remains to have a certain bolt works and a certain manufacturing company adopt the same quantities.

It would be the suggestion of this committee that the quantities shown as standard be added to the requisition forms and orders of all P.C.E.A. member companies.

With regard to porcelain insulators, C. A. Kelley's committee will furnish a list of the sizes and catalog numbers now in use by central stations on the Pacific Coast. It also is understood that they will attempt to reduce this list. At that time this list will be forwarded to the National Porcelain Insulator Manufacturers Association, through A. W. Pride of this committee and he will ask them to submit standardized packing quantities for these various sizes.

It is generally understood that the porcelain association is making considerable headway and it is quite possible that it will have reached the matter of standard packages by the time the list has been prepared in which case the matter will be taken care of automatically. In fact, the investigations of this committee would indicate that the manufacturers of the various products supplied to the electrical industry have gone far toward solving the standard package problem as well as on other simplification problems on their own account, the result no doubt of continual pressure from Mr. Hoover's Department of Commerce.

Utilities' Standpoint on Standardization of Packages

Standardization of packages from the utilities' standpoint, more or less depends upon the final adoption of such classes of material as pole-line hardware, insulators, etc, and should be worked out from that point of view. However, there is no question but that a great amount of money could be saved both by the manufacturer and the utilities if standard packages were adopted. This volume production would decrease the cost both to themselves and to the actual consumer. Storage space also could be saved since uniform packages could be stacked to a higher level. Time also would be saved in counting the content and in making claims against transportation companies for shortages in packages and broken material in transit, due to improper packing.

Surplus stock could be warehoused in a more neat and orderly manner. Burlap sacks have proved unsatisfactory for the reason that they are easily torn and heavier classes of hardware will wear holes in them in a very short time. Substantial barrels are satisfactory for some classes of material.

It has been suggested from a utility standpoint that soft pine boxes be used and, if necessary on account of the weight they contain, that they should be strapped at each end either with flat box strapping or tie wires, using care of course to see that no sharp ends are left. Boxes should all be stenciled on one end, at least as to the content and quality contained therein.

Suggested recommendations are as follows:

Insulators.

11-kva. and 22-kva. pin-type insulators should be packed in wooden crates, 6 insulators to the crate.

66-kva. suspension-type insulators should be packed 6 to a crate.

Secondary glass pin-type insulators should be packed 100 to a box.

Strain insulators should be packed 12 to a crate.

Strain insulators for guying should be packed 50 to a box.

Spool insulators such as used for primary and secondary dead-ends should be packed in a standard box, 100 to a box.

These quantities as suggested may not be satisfactory to all companies concerned.

Pole Line Hardware. The following suggestions are offered:

⅝-in. machine bolts, 10 to 18 in. long, inclusive, 100 to the case.

Three-bolt guy clamps, 100 to the case.

⅝ x ⅝-in. lag screws, 100 to the case.

Double arming bolts, ⅝ x 16-in., 18 and 20-in., 100 per case.

Square washers, $\frac{5}{16}$-in., 2¼ x 2¼ in., 100 per case.

Square washers, ¼ x 4 x 4-in., 250 per case.

It has been recommended by other utilities that guy clamps be packed in standard nail kegs, which are stronger because of being reinforced with steel hoops and are much easier to handle than boxes.

Statement Showing Quantity of Pole-Line Hardware to Be Packed in Standard Packages

Description	Mfrs. Std. Pkg.	Utility Std. Pkg.
BOLTS		
Arming, double—	Box of	Box of
⅝ x 16 in.	50	50
⅝ x 18 in.	50	50
⅝ x 20 in.	50	50
⅝ x 22 in.	50	50
⅝ x 24 in.	50	50
Eye—		
⅝ x 8 in.	50	50
Machine—		
⅜ x 3 in.	500	500
⅝ x 3½ in.	500	500
⅝ x 4½ in.	500	500
⅝ x 5 in.	500	500
⅝ x 6 in.	500	500
½ x 4½ in.	250	250
½ x 8 in.	200	250
½ x 10 in.	100	250
⅝ x 6 in.	100	100
⅝ x 8 in.	50	100
⅝ x 10 in.	50	100
⅝ x 12 in.	50	50
⅝ x 14 in.	50	50
⅝ x 16 in.	50	50
⅝ x 18 in.	50	50
⅝ x 20 in.	50	50
⅝ x 22 in.	50	50
⅝ x 24 in.	50	50
⅝ x 26 in.	50	50
⅝ x 28 in.	50	50
¾ x 8 in.	50	50
¾ x 10 in.	50	50
¾ x 12 in.	50	50
¾ x 14 in.	50	50
¾ x 16 in.	50	50
¾ x 18 in.	50	50
¾ x 20 in.	25	25
¾ x 22 in.	25	25
¾ x 24 in.	25	25
¾ x 26 in.	25	25
½ x 6 in.	250	250
BRACES		
Angle, double span—	Bdls. of	Bdls. of
1½ x 1½ x $\frac{5}{16}$ x 59 in. (Dealer's list shows 60 in.)	5	5
Crossarm, flat—		
1¼ x ¼ x 32 in.	20	20
CLAMPS		
Guy—	Box of	Box of
2-bolt	200	100
3-bolt	125	50
HOOKS		
Guy—		
1½ x ⅝ x 6 in. 2-bolt	100	100
RODS		
No-thimble eye anchor—	Bdls. of	Bdls. of
⅝ in. x 6 ft.	10	5
¾ in. x 8 ft.	5	5
1 in. x 10 ft.	3	3
SCREWS		
Lag, fetter drive—	Box of	Box of
½ x 4 in.	500	500
½ x 6 in.	500	250
STEPS		
Pole—		
$\frac{5}{16}$ x 9 in.	100	100
THIMBLES		
Wire rope—		
⅝ in.	1,000	500
½ in.	500	500
⅝ in.	250	250
WASHERS		
Round—	Box of	Sacks of
For ⅜-in. machine bolts	5,000	25 lb.
For ½-in. machine bolts	2,500	50 lb.
For ⅝-in. machine bolts	1,000	50 lb.
For ¾-in. machine bolts	1,000	50 lb.
Square—	Box of	Box of
2 x 2 x ⅛ in.	500	500

It has been recommended also that items such as lag screws, pole steps and washers be packed in standard kegs instead of boxes, the reason being that the boxes break more easily when handled and are more cumbersome than kegs. The advantage that the box has over the keg is that the box is more easily stacked.

It has been recommended by some companies that all utilities agree upon a standard length coil of guy wire. The following lengths are given as example:

7/16-in. guy wire, purchase 50 per cent 200-ft. coils and 50 per cent 300-ft. coils.

⅜-in. guy wire, purchase 25 per cent 300-ft. coils and 75 per cent 200-ft. coils.

Several companies complain that No. 8 weatherproof wire, solid copper especially, is very heavy and in view of the fact that men on the service trucks are generally working alone the weight of this particular wire makes a coil too heavy and cumbersome to handle.

Accompanying this report are two lists of pole-line hardware with reference to standard packages for the various items shown. On list No. 1 the first column shows standard packages of one of the manufacturers of pole-line hardware. Column No. 2 shows the quantities one of the utilities would prefer as standard package. List No. 2 shows materials which usually are carried in utilities stock and the type of package the manufacturer uses.

Quantities, etc., shown on these lists should be open for discussions, but as stated in the beginning of this report, much depends upon the standardization of pole-line hardware and other materials.

Simplified Invoices

The "simplified invoice" committee on co-operation with the National Association of Purchasing Agents, is endeavoring to promote a wide-spread adoption of the simplified invoice as approved and recommended by the Division of Simplified Practice of the Department of Commerce. This invoice has been accepted by 38 nationally known trade and professional associations, and has been adopted and is used by thousands of firms in the United States.

A bulletin issued by the Department of Commerce, "Simplified Practice Recommendation R37-38," gives the following reasons why the simplified invoice form should be adopted:

> "Those in a position to know state that this invoice will save industry $15,000,000 yearly. It will reduce checking, paying, recording, filing, and finding expenses; but these savings will be realized to their fullest extent only in case every individual will extend his co-operation by adhering to the approved recommendation. The important point is to secure the participation of all interests. Those who adopt the new standard not only gain for themselves the economies and increased efficiency inherent in this simplification measure, but transmit these benefits to those with whom they do business. It is earnestly hoped that all users of invoices, regardless of type, will change to the 'simplified invoice' as soon as their present supply of forms is exhausted."

This committee has found that there is a general opinion that there is a number of so-called standard invoices. There is **only one approved and recommended invoice,** and that is the "simplified invoice."

A number of firms have reported that invoices received on the simplified form are passed for payment more quickly because of the ease in checking. Co-operation of every utility organization in the movement by adopting the simplified form as the billing medium is asked. For further information address, Simplified Invoice Committee, P.C.E.A., Room 666, Chamber of Commerce Building, Los Angeles.

Catalogs

This committee is studying all types of catalogs and will report its findings later.

See Part III 1929 Proceedings for written discussions and for reports presented for publication subsequent to April 1, 1929.

Transportation Section[1]

Vehicle and Body Design

By R. V. DODGE, JR.*

TO THE casual observer the need for an extensive study of vehicles and body designs may not be obvious. To meet the demands for transportation for an additional line construction crew, as an example, he may have formed an impression that all that has to be done is to go out and buy any truck chassis, put on a cab and body, furnish a driver and the line truck is ready. This precedure may have been altogether fitting and proper in the early stages of the transportation era but times have certainly changed.

Points for Consideration

At this date, many factors govern the selections including dependability, suitability, adaptability, convenience, comfort, safety, economy and appearance.

Selection of Chassis — The selection of a proper chassis should unquestionably be left entirely with the head of the transportation department and his recommendations should be followed. He should make a thorough study of the mechanical details to determine if sufficient motive power will be available, if the structural members will be sufficiently rugged, if the power transmission will give the proper speeds and will be free from costly failures, if there will be sufficient rubber in the tires to comply with state and local laws and to give economical life, and so on.

Cab Design—The design of the cab is important also and here all the points of view must be considered. The size, style and weight deserve careful attention,

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[1] **J. M. Wainscoat,** San Joaquin Light & Power Corporation, chairman. **C. D. Weiss,** San Diego Consolidated Gas & Electric Company, vice-chairman. **R. E. Kempton,** San Joaquin Light & Power Corporation, secretary. **Coast Counties Gas & Electric Company:** A. E. Strong. **Coast Valleys Gas & Electric Company:** G. A. Peers. **Elko-Lamoille Power Company:** B. G. McBride. **Great Western Power Company of California:** F. W. McGuire, J. S. Moulton. **Los Angeles Gas & Electric Corporation:** R. U. Fitting, W. J. Schaeffer. **Pacific Gas and Electric Company:** S. B. Shaw, E. C. Wood. **Pacific Telephone & Telegraph Company:** V. W. Dennis. **Sierra Pacific Power Company:** E. D. Brown. **Southern California Edison Company:** P. H. Ducker. **Southern California Telephone Company:** W. H. Fairbanks. **The Southern Sierras Power Company:** C. H. Gray.

* Report of vehicle and body design committee, Transportation Section. C. D. Weiss, chairman.

impairment of vision should be minimized, protection from inclement weather should be afforded, upholstering and leg room should be sufficient for comfort and safety should be considered.

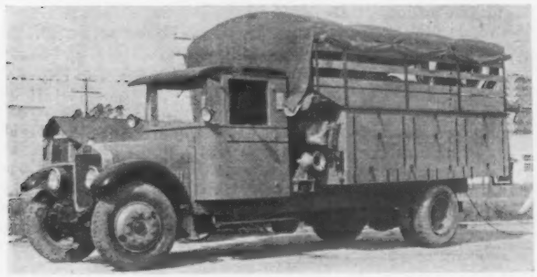


Fig. 1. Side view of special line truck designed for utility service.

Auxiliary Apparatus—When it comes to the auxiliary apparatus, there is need for the co-operation between the heads of the line construction department and the transportation department to determine just what is required and what makes best fulfill the specifications. This covers such items as winches and pole setting derricks. In these selections, consideration should also be given to safety features; for example, winches of the self-locking type being safer than those relying entirely on brakes to hold the load.

Body Design—In planning the body proper, there is great need of co-operation among the departments and those charged with building the bodies should encourage and carefully consider all suggestions. The amount of material and tools required by the average construction crew is truly amazing, particularly evident when the articles are spread out on the floor or ground for inventory. The old adage "a place for everything and everything in its place" is a premise for economical operation and space is limited. Ease of obtaining the article sought without having to "paw" over or unload other material will speed up the work on the job. Another important feature is the seating arrangements. The men should be made as comfortable as possible while en route and care should be exercised that they be carried safely.

Keeping Down the Dead Weight

Weight is a necessary evil and this applies not only in the dead weight of the body and boxes, but also

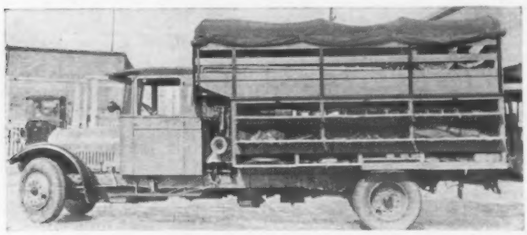


Fig. 2. Special line truck showing arrangement of compartments.

in the stock of materials and tools. The bodies and boxes must be made strong enough to sustain the superimposed loads and impacts and to resist the wear and tear. Wood and steel are used extensively in body construction and there must be great possibilities here for the use of lighter plates and structural shapes of aluminum alloys when a commercially satisfactory product is available. At the first glance the cost of aluminum bodies may appear to be prohibitive, but it

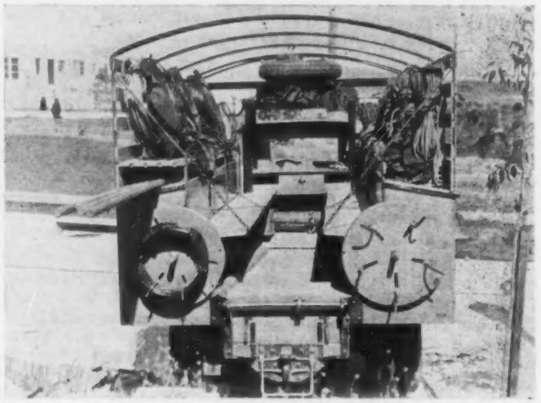


Fig. 3. An additional reel replaces the ladder and continuous seats replace the sectional seats thereby increasing the seating capacity to seven on each side.

must be remembered that it is the ultimate cost that counts. Aluminum bodies are said to cost approximately twice as much as steel, but decrease the weight, for equivalent strength, one-third or more. The final economy can readily be determined if the average hauling cost per ton-mile be known, figuring on the probable milage life of the truck and taking into consideration the greater salvage value to be derived from scrap aluminum. Companies operating fleets of trucks fitted with van bodies are using aluminum products to advantage. On one job mentioned, the weight of the van was reduced from 3,500 lbs. for the conventional type to 2,160 lbs., the cost being about $2000. The use of aluminum has been well developed in automotive motor and transmission parts and in airplane construction, but in application to truck bodies its advantages apparently have not been fully recognized.

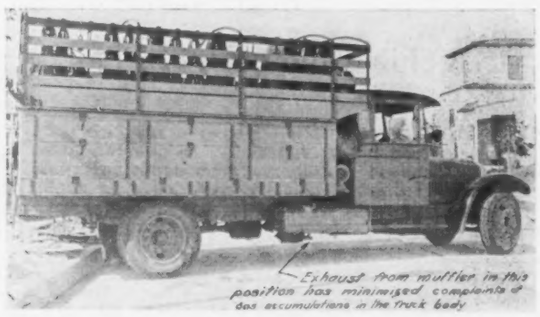


Fig. 4. Side view of line truck showing arrangement of exhaust pipe from muffler which results in least accumulation of exhaust gases in truck body.

There are many opportunities for great assistance from the construction department head and foreman in reducing transportation operating costs if the amounts of material be kept as low as practical, thus minimizing the load to be continually hauled around.

Neatness Becomes a Prime Requisite

It must be remembered at all times that the cars and trucks of a public utility are essentially moving advertisements of the company and that the consumers are likely to judge the company by the appearance of its equipment. It therefore behooves both the line construction department and the transportation department to exert efforts to keep the trucks looking neat. Good housekeeping should be insisted upon by carefully stowing all material and tools and by eliminating overhanging articles as far as can be avoided.

A Typical Line Truck

Accompanying illustrations show the latest type of line trucks placed in the service of the San Diego Consolidated Gas & Electric Company. This design essentially follows the style of body adopted by the Byllesby Engineering and Management Corporation in its Eastern properties but has been modified to meet certain local needs.

Description of Chassis—The chassis is the White Company's 2.5-ton model 51-A, 4-cylinder motor, with compound transmission and 36x8-in. heavy-duty cord tires, dual on the rear axles. This truck or any similarly constructed truck of reputable manufacture is capable of handling 20,000-lb. gross loads. The chassis is equipped with electric lights and starter, air cleaner, overload springs and a 35-gal. gasoline tank, located on the right hand side to the rear of the cab.

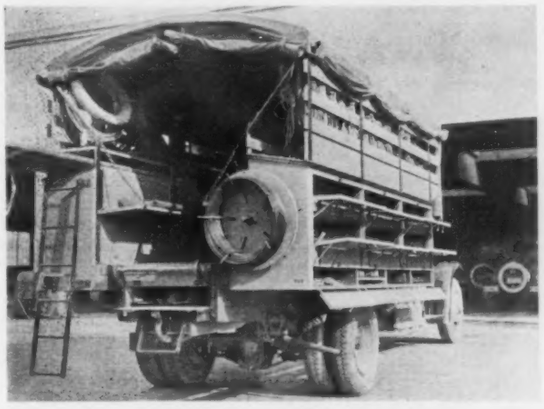


Fig. 5. Showing arrangement of compartments and one of the experimental locations of the muffler exhaust pipe.

Cab—The cab is of the vestibule or enclosed type and is of composite construction, wooden framework with sheet steel sides with aluminum castings in the windshield frame. A large "drop" type window is placed in the back of the cab, through which the driver can obtain unobstructed view of the winch cable. Spot lights and the rear view mirror have been added.

Auxiliary Apparatus—The chassis is fitted with the truck company's own model of power driven winch with control levers in the cab. The winch has double extended niggerheads or gypsies, from which lines may be pulled over the front end of the truck. The main drum holds easily 750 ft. of half-inch 6x37-strand wire rope. A pole-setting derrick was not required on this truck.

Body, Material and Tool Boxes and Appointments—The body and boxes were built in the company's shops. The sills, cross members and floor of the body are made of hardwoods, the boxes being of pine reinforced with steel shapes and sheets. A compartment, made between the sills with a drop door at the rear, is utilized for digging bars and tamping poles. The compartments between the cross members with drop doors at the sides hold shovels, cross arms, brooms, fibre conduits, sledge hammers, etc. Material and tools are carried in the boxes which are also fitted with drop doors at the sides of the truck.

Pike poles and spoons are carried on the top of the box on the left hand side and rope lines and coils of wire are hung on movable hooks from the top iron of the frame above the boxes. "Lift-up" seats are attached to the boxes. A desk for the foreman is formed over the winch in the framework which provides support for the spare tire. On the rear end, in addition to the trailer hitch and step iron, a sheave which slides on a shaft has been mounted. A groove of the sheave accommodates the wire rope from the winch and reduces the wear on the latter.

"Desert" water bags are used in lieu of water kegs. These are suspended from hooks attached to the ends of the boxes above the niggerheads. This place insures good air circulation, thereby keeping the water cool by means of the evaporation effect. Just above the clearance light may be seen the holder containing paper drinking cups.

Fig. 6. Equipment arrangement provides maximum flexibility.

A "pay-out" reel holding insulated wire is shown attached to the rear end of the box on the right hand side and the ladder opposite has been replaced with an additional reel, as the step iron under the trailer hitch gives sufficient ease of access.

The tarpaulin which gives protection from the weather is supported by bows and can be removed during the summer months if desired.

Functions of the Vehicle and Body Design Committee

From the foregoing it is evident that the vehicle and body-design committee of the P.C.E.A. Transportation Section can be of considerable benefit to the member companies in acting as a clearing house for developments in car and truck models and in body and box layouts. In such a committee, the merits can be discussed fully and ideas can be exchanged to the end that the service rendered by the transportation facilities may be constantly improved. It is the desire of all members of this committee to work with every other section of the Association interested for the purpose of developing the best suited and most economical designs in automotive equipment for the particular purposes of our phases of the electric industry.

Transportation Department Organization

By S. B. SHAW*

THE COMMITTEE on maintenance and organization has undertaken to compile comparative data on the organization of transportation departments of member companies. Two questionnaires were sent out. The first related to number of vehicles per employee and was intended to show relative number of vehicles per employees under different conditions of maintenance. The second was intended to show the various titles and payroll classifications used and the kind of work in which proficiency is required for each classification.

Vehicles Per Employee and Classes of Work Performed

Accompanying Table I shows a summary of this data for four members reporting. The number of vehicles per employee varies from 7.03 to 15.2 Considering the main classes of employee, we note that "supervision" varies from 51.0 to 118.7 vehicles per man, "mechanics and shopmen" from 11.9 to 41.0, and "garage and service men" from 25.9 to 39.5 vehicles per man.

Examining the data as to classes of work performed by transportation department employees in company shops and garages, we find that, with the exception of one company, at least part of every class of work except radiator repairs is done in company shops. The classes of work, the smaller percentages of which are generally done in company shops are top and upholstery repairs, body and fender repairs, battery repairs, carburector repairs, cylinder repairs and electrical repairs, all more or less specialized work requiring special tools and equipment. There appears to be a greater proportion of these classes of work sent to commercial shops by the less centralized organizations.

Classification of Employees

From questionnaires returned a compilation has been made, as shown in the following tabulation, to show the various classifications into which transportation department employees are divided by the several companies. The number of classifications used in each case varies somewhat with the scope of the department's activities. Thus some organizations provide for chauffeurs, truck drivers and dispatchers while others do not. The scheme of organization and method of handling work also affects the classifications, as for example in certain cases traveling mechanics, vehicle inspectors, etc., are listed while other organizations do not provide for them.

TABLE I—Vehicles per Transportation Department Employee and Classes of Work Performed

Reporting company	A	B	C	D
Number of motor vehicles operated	658	356	1,346	970
No. of trans. dept. employees				
Supervisory	9	3	13½	19
Mechanics and shopmen	16	11½	91	81½
Garage and service men	19	9	43	37½
Total	44	23½	147½	138
Ratio vehicles to employees				
Supervisory	73.2	118.7	100.0	51.0
Mechanics and shopmen	41.0	31.0	14.8	11.9
Garage and service men	34.6	39.5	31.3	25.9
All Classes	14.9	15.2	9.12	7.03
Classes of work performed by employees listed above. Index shows proportion of work done by company shops—				
Field supervision	1.0	0.0	0.0	1.0
General overhauling	0.0	1.0	1.0	1.0
General repairing	0.0	1.0	1.0	1.0
Trouble shooting	1.0	1.0	1.0	1.0
Body and fender repairs	0.0	1.0	0.3	1.0
Top and upholstery repairs	0.0	1.0	0.1	1.0
Body building	0.0	1.0	0.5	1.0
Electrical repairs	0.0	0.0	0.4	0.5
Battery repairs	0.0	1.0	0.2	1.5
Radiator repairs	0.0	0.0	0.0	0.0
Cylinder refinishing	0.0	1.0	0.1	0.0
Bearing installation	0.0	1.0	0.9	0.0
Carburetor repairs	0.0	1.0	0.3	0.0
Relining brakes	0.0	1.0	0.9	1.0
Painting	0.0	1.0	1.0	1.0
Washing and polishing	1.0	1.0	1.0	1.0
Lubrication	1.0	1.0	1.0	1.0
Gasoline service	1.0	1.0	1.0	1.0

In the larger shops where all manner of work is handled, quite a variety of specialists are employed. In other cases this work is either sent to commercial shops or handled by men listed as mechanics.

It is believed that the number of classifications can be materially reduced and discussion by members of the section is invited. If work and workmen could be more definitely classified, comparisons between various organizations could be more readily made.

* Report of organization and maintenance committee, Transportation Section. S. B. Shaw, chairman.

Supervisory Personnel

1. Superintendent of transportation
2. Motor vehicle supervisor
3. Master mechanic
4. Foreman
5. Inspector
6. Dispatcher
7. Clerk.

Shop Personnel

1. Mechanic
2. Repairman
3. Helper
4. Apprentice

Shop Personnel—Specialized

1. Electrician
2. Trimmer
3. Tireman
4. Batteryman
5. Painter
6. Machinist
7. Blacksmith
8. Woodworker
9. Welder

Garage Personnel

1. Car cleaner
2. Serviceman
3. Janitor
4. Watchman.

Others

1. Chauffeur
2. Truck driver
3. Storekeeper
4. Truck driver helper

Safety Railings for Service Pits

By R. V. DODGE, JR., and C. D. WEISS*

ALL LAWS relating to industrial safety demand that pits be protected with railings. Of course, permanent railings are impractical around service pits in garages and automotive rapair shops as the cars and trucks must be driven over the pit. Therefore some type of movable or removable railing must be installed.

Upon receiving the recommendation from its accident prevention committee that the service pit in the storage garage of the San Diego Consolidated Gas & Electric Company be protected, the railings shown in the photographs were devised. The posts are formed from 1½-in. pipe, the side rails of 1¼-in. and 1-in. pipe. To one post is attached, by means of eyes and a cap a 3-ft. length of 1-in. pipe. This section is inserted in the 1¼-in. pipe which is similarly attached to the next post, the length of the 1¼-in. pipe being less than the distance between the caps. Sockets for the posts are attached to the sides of the pit, the tops being notched to receive a pin inserted through a hole in the post at the proper height. 2 Chains are placed across the ends.

One of the views shows the railing in normal position. To drop the railing to allow a car to pass over the pit the end chains are unhooked, the pins are pulled out and the posts are dropped, one after another into the sockets. Another view shows the entire railing lowered

* Report prepared for shop practices and equipment committee, Transportation Section. E. C. Wood, chairman.

while the other two illustrate the flexibility of the arrangement. One half may be lowered by dropping four posts in the event that the car does not have to pass completely over the pit. The one showing the railing in a "trust" position reveals clearly how the 1¼-in. pipe rail slides on the 1-in. section.

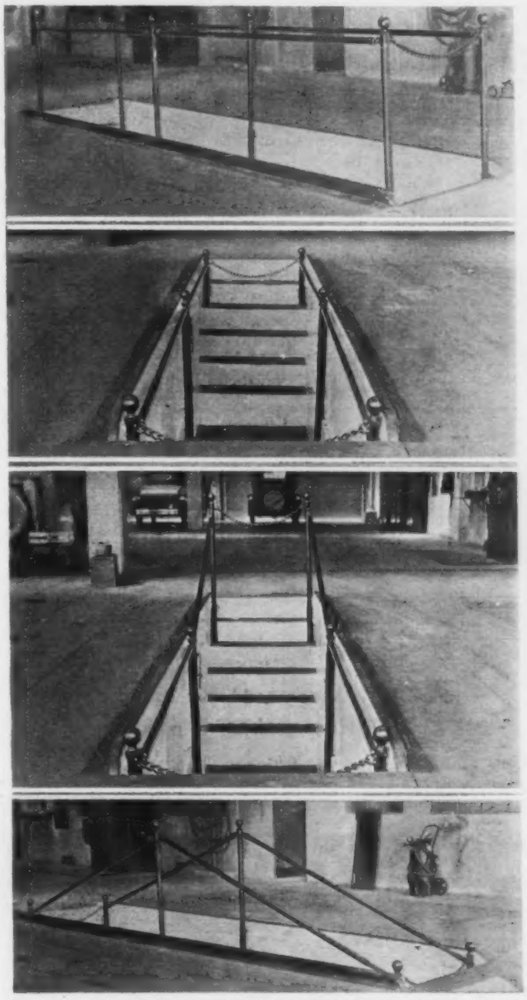


Fig. 1. A novel protective railing for a service test in a utility garage. Top view shows the railing in normal position. Second view shows railing dropped to permit passage of cars over pits. Third view shows half of railing lowered, other half raised. Lower view shows further the flexibility of the railing, illustrating how the 1¼-in. pipe rail slides over the 1-in. section adjacent to the end posts.

To raise the railing to normal position the operations are reversed. One post at a time is lifted, the pin is pushed through the hole and seated in the notch in the top of the socket. Note that "keeper" chains are attached to the pins, so that they will not be mislaid. Finally the end chains are replaced. Notices will be posted to the effect that whoever lowers the railings will be held responsible for replacing them.

Incidentally, a piece of 8-in. H-beam has been set into the walls of the pit and, with the aid of suitable clamps and hydraulic jacks, is used to correct the camber of axles and to make other wheel adjustments and also to facilitate the removal of springs.

This description and the illustrations are reproduced merely for the purpose of passing along to other members this unique solution of a safety problem for whatever it may be worth. The raising or the lowering of this type of railing is a one-man operation.

Shop Practices and Equipment*

TO generalize on the shop equipment needed to meet the demands of the fleet operator, it is necessary to consider first the different classifications of work or unit operations and the respective types of business. It it self-evident that the equipment necessary for the unit-replacement system of operation must be as flexible as possible where both light vehicles for rapid transit and heavy equipment have to be placed in the field and maintained in service at a reasonable cost, and delays held to the minimum.

The condition that is common to all the branches of the automotive industry is the rapid change in the design of motor vehicles. Consequently, the fleet operator is confronted with the questions: How long a life has the equipment before becoming obsolete? What is the time limit for the return of the investment? Is it cheaper to install the equipment or "farm the work out" to shops equipped to do this work? Considering that the production methds and the designs in the automotive industry change in a period of about eighteen months, special equipment becomes obsolete long before it is worn out and in a short period, the tool room is a collector of obsolete devices.

The problem that develops is whether the special jig, fixture or special device can be so constructed that when changes are made the major part can be used in conjunction with some complementary part and thus make the tool efficient. In many cases, it is well worthy of a greater amount of study in designing these special tools to consider their period of use, their flexibility and interchangeability, and in this way to produce efficient labor-saving devices at minimum cost.

To cover the range of work that the fleet operator requires practically demands the installation of standard machines. If the fleet operator would devote a little more attention and study to the engineering features of proposed shop equipment he would be well rewarded by better-adapted machines, greater efficiency, better safety conditions and a higher morale in personnel.

The lighter and mobile equipment in the fleet operator's shop will bear the same survey as that of the heavier equipment and needs as much study and consideration as to limits of precision and efficiency. As the fleet operator is continually confronted with the problems of lower maintenance and operating costs, it is necessary that the shop of the organization be equipped with efficient labor-saving devices.

With the units receiving service in a fleet-owner's plant much interest was taken in the plans and design of the building to provide the utmost daylight on the units and equipment. The layout of the shop was so that the unit makes a complete cycle, or could be switched from one department or station to any other in the plant. The crane system was constructed and operated so that the unit or any part could be transferred to any department or station.

Reducing Repair Costs

Some of the features that reduce the cost of repairs include the installation of major-repair bays

* Report of shop practices and equipment committee, Transportation Section. E. C. Wood, chairman.

giving the mechanic full access to the under part of the vehicle at the proper working height. These bays consist of a portable bench for the assembly and fitting of parts. The main trench gives ample room for the workman. Each bay is equipped with an electric light and an electric-tool outlet and an air outlet. The bays are ventilated and drained, and an exhaust system is provided to remove fumes while the engine is running. An overhead crane system is efficacious in handling dismantled parts to the cleaning solution, and transferring them to their proper overhaul or repair stations.

The overhaul station performs a distinct function in the unit's assembly or repair of the individual parts. These stations are of the portable type and consist of portable benches with the necessary tool equipment on portable stands. As each station handles a certain part, such as the transmissions, the differential, etc., the unit can be taken readily to the assembly bay and installed on completion of its repair. As the tool stands are portable they can be replaced or drawn from the stock room. One of the advantages of this system is that the shop can operate always at the best advantage. With this means, also, the shop can be cleaned easily and foreign material disposed of quickly.

The linkage between the engine assembly room and the repair floor should be direct, the latter being equipped with overhaul benches, running-in stands and devices for efficient operation on engine overhaul. Next in the cycle and adjoining the engine assembly room is the machine shop. The equipment should be sufficient to handle the average work that is met by the fleet operator, from a complete reconstruction to the designing and making of jigs, fixtures and special tools. The blacksmith shop comes next in order, equipped with gas- or electric-operated fires, a drop hammer, tempering furnaces and a full line of hand tools. The carpenter and body department should be adequate to handle the building and repairing of bodies and miscellaneous carpenter work.

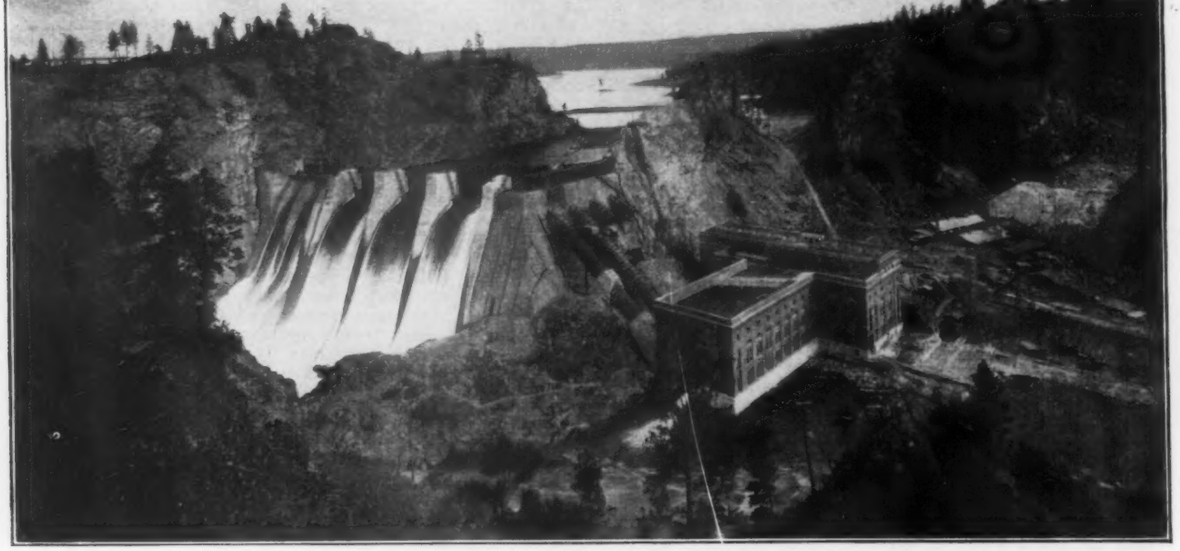
The grease and oil racks of the air-hydraulic or the electric type should be connected so that refilling, draining and flushing operations can be accomplished by short hose connections from a magazine lubricator. Wash rack and steam cleaing plant should be designed to accommodate vehicles with adequate working space between them. The hoisting device should give ample room for the cleaning of the running gear and the under-chassis mechanism. The wash rack should be equipped with hot and cold water, air, steam, and cleaning solutions, and it also should be efficiently drained.

The battery and electric departments should be located for accessibility, and efficiently equipped with test apparatus and special tools and devices. The tire repair shop should be of modern design and fully equipped. The parking area for the light-weight vehicles should be designed so that in wet weather the units can be cleaned in their respective parking plots and the drainage quickly disposed of. The fueling bays should be conveniently located.

With the described method of handling equipment, the flexibility of the shop is such as to make rearrangement to handle the conditions feasible, and with this arrangement, a saving of labor and time factor is effected. The cycle of operation is considered economical because a unit can be diverted so that proportional repairs can be made, or it can complete the cycle. With such range, any system can be installed to meet the specific needs of the operator.

Deciding factors that go into the purchasing of a piece of equipment to be put into a fleet operator's shop seem to be:

Improvement in operating methods.
Character of the construction.
The maintenance.
The investment cost.
The depreciation.
Obsolescence.



A Good Year for the Northwest

By R. M. BOYKIN

President, Northwest Electric Light and Power Association.

THE association year now drawing to a close has been marked by the usual healthy activity that has characterized the operations of the Northwest Electric Light and Power Association in recent years. During the current year 44 committees have functioned in the four sectional classifications, and interest among member companies and their employees in the many phases of association work has been manifest. Many of these committees are publishing their year's report in the following pages, and a perusal of these reports is recommended not only to the rank and file of company organizations interested in a particular branch of utility operation, but also to the executive who may find therein something having a bearing on his own company problems.

R. M. BOYKIN

It is scarcely necessary at this time to draw attention to the value to member companies of association work. I believe we are all agreed that the various studies undertaken by the association in the past have contributed in a marked degree to the advancement of our industry. I believe we can all look into our own company operations and see reflected therein the results of co-operative studies completed by association committees.

In the brief space allotted, I cannot review the entire association year in all its phases. With the assurance that I will not be misunderstood by not referring to all the reports that follow, I would like to call attention to some of the high lights of the various activities of the sections, which can be scrutinized in more detail in the published reports.

In the Accounting Section the fixed capital committee has gone into the subject of the use of fixed capital records in the preparation of insurance schedules. This report brings out quite clearly how essential it is to maintain certain records with respect to insured properties so that premiums can be kept at a minimum, and so that possible losses will be fully covered. The statistics committee indicates in its report a very compact manner of rendering monthly statistics to the executive so that he can quickly grasp those fundamental features of his company's operations that he needs for the guidance of his conduct of the business.

In the Commercial Section the farm electrification committee has been most active and the fact that there are now approximately 64,000 farms receiving central station service in the territory served by this association's member companies is an indication that a more complete understanding by the member companies of the problems involved is being brought about.

Among other interesting Commercial Section reports are those of the street and highway lighting committee, which completes a three-year study, taking up this year the methods by which street lighting can best be sold; the electrical advertising committee, a new one in this geographic division, which shows the enormous market available in this field and discusses a number of the elements entering into the process of building this type of load; and the water heating committee, which also issues its first report this year in the form of a survey of company practices, laying the foundation for further study.

In the Engineering Section the usual wealth of instructive material was presented at the section's annual midwinter meeting, and this will be published in a separate pamphlet, as has been customary in recent years. In addition to the subjects discussed at that meeting, tests were conducted on Neon signs, disclosing the power factor characteristics of this type of sign. Two other subjects of great importance to Northwest companies on which studies were conducted during the past year, were the fishway problem and radio interference from high tension insulators. Among the Engineering Section reports printed in the following pages will be found a resume of the fishway situation, telling of the headway being made toward the solution of this knotty problem and outlining experiments in the control of migratory fish to be conducted during the coming year. It is also probable that the study of radio interference from transmission lines will be continued.

One of the principal features of the work of the Public Relations Section during the past year has been to conduct again public speaking and essay contests designed to arouse an interest among the rank and file of company employees in the problems of the utility business. The winners of these contests will be heard at the coming convention.

Following the usual custom, the business programs will be general in character, to appeal to persons engaged in all branches of the industry.

May I take this opportunity to invite the association membership and all others who may be interested to join us in Seattle in June.

Accounting Section Reports[1]

CUSTOMERS' RECORDS COMMITTEE

Customers' Records*

THE customer's records committee selected for study during the year of 1928 the subject of bi-monthly billing and the subject of credit policies. It was the opinion of the committee that although plans for rendering bills to customers had been studied sufficiently for the time being, there undoubtedly were minor innovations or "wrinkles" in customer billing work which should be reviewed and passed on to other accounting members.

The subject of bi-monthly billing was assigned to N. B. Whittier, customer office manager, Portland Electric Power Company. This company has been following the plan of bi-monthly billing for more than ten years. Under the heading of credit policies, F. L. Nagel, supervisor collection bureau, Northwestern Electric Company was assigned a study of the advantages and disadvantages of the "Courtesy Card" plan versus the "Exchange of Credit Information" plan.

Several "wrinkles" in customer billing were given consideration by the committee. The only "wrinkle" to be reported on at this time is "billing even consumptions." This report was prepared by C. R. Johnson, supervisor customer billing bureau, Northwestern Electric Company. These reports follow in full.

* Report of customers records committee—**B. H. Parkinson,** Pacific Power & Light Company, chairman. **N. B. Whittier,** Portland Electric Power Company, vice-chairman. **Idaho Power Company:** J. F. Cooper. **Northwestern Electric Company:** F. L. Nagel. **Portland Electric Power Company:** C. P. Milne. **Puget Sound Power & Light Company:** E. P. Donnegan. **Utah Power & Light Company:** Henry Mann. **The Washington Water Power Company:** L. E. Morse.

Bi-monthly Billing

By N. B. WHITTIER*

IT IS possible for public utilities to effect considerable economy in customer's accounting costs by rendering bills for periods longer than one month. It has long been the practice with certain gas and water utilities to render bills on a bi-monthly and even quarterly basis. During the war period, at least three large electric utilities adopted bi-monthly billing, and one resorted to quarterly billing as an emergency measure. Each of these utilities still maintains the plan and is satisfied that it is economical and feasible.

Bi-monthly billing for electric utilities is ordinarily restricted to residential consumers and small business houses in residential sections. Not only would the majority of large commercial and industrial houses insist upon monthly statements, but the amount of revenue involved is too great to justify any saving in accounting costs which might result from a longer billing period.

With a bi-monthly plan, therefore, a city is usually divided into two areas, one representing the business district, which is billed monthly, and the other, the residential area, which is billed on a bi-monthly basis. Should it be considered advisable to read and bill all commercial accounts in the residential area on a monthly basis, this can still be accomplished more economically than if all accounts are handled monthly.

* Report presented to customers records committee.

[1]Executive Committee—A. E. Janssen, Idaho Power Company, chairman. M. J. Wilkinson, Pacific Power & Light Company, vice-chairman. F. W. Brownell, B. G. Gadeholt, D. F. McCurrach, L. E. Hinman, R. H. Jones, B. H. Parkinson, W. F. Miller.

Economies

The direct economies resulting from bi-monthly billing are quite easy to compute and occur in the following accounts:

1. Meter reading.
2. Bookkeeping labor.
3. Cashiering.
4. Stationery, printing and addressographing.
5. Postage and bill distributing.

The saving in stationery, printing and postage is in direct proportion to the number of bills rendered. With respect to meter reading, it is necessary to take into consideration the character of the districts involved, the saving being one-half of the time required to read the residential areas.

With bi-monthly billing, the ledgers need to be closed only once every two months. There is saving, therefore, of 50 per cent of the clerical help required in billing, posting cash, balancing and abstracting and classifying revenues on the ledgers pertaining to the residential areas. No saving will be made in the labor required to secure contracts, open and close ledger accounts and to render final bills.

Determining Factors

While the advantages of bi-monthly billing are quite apparent, the disadvantages and the factors which must be taken into consideration before adopting the plan are intangible and difficult to evaluate. These conditions tend to offset the economies from bi-monthly billing and would become relatively more important if the billing period were still further extended.

1. Nature of Population.—The degree of stability and permanence of the population require considerable thought in determining the length of the billing period. At vacation resorts, where the population is highly transient, it is frequently necessary to render bills as often as once a week. Similarly, in towns and cities where the population has a tendency to migrate with seasons, bills must be rendered more frequently than is necessary in a stable community.

Industrial conditions also have a direct bearing upon the problem, as for instance, in a small town where the majority of the people are dependent upon a single industry for their support. Consideration must be given in this instance to the possibility of such an industry being shut down at intervals. Occasionally two or more industrial centers are located close together and there is a tendency for the wage earning population to shift from one city to the other in accordance with the working conditions.

In general it may be said, however, that bi-monthly billing is practical in stable agricultural communities and in cities and towns of any size enjoying diversified industrial conditions.

2. Amount of Average Monthly Bills.—Bi-monthly billing is particularly adaptable to water companies where the average monthly bill is relatively small. On the other hand, it is quite out of the question for a gas company doing a large amount of house-heating business. The average electric utility lies between these two extremes. Although the average bill may be high in certain communities where cooking and water heating are done electrically, the people in these communities are able to make their payments on a bi-monthly basis without difficulty. This statement is borne out by the experience of companies operating on the bi-monthly plan in districts where the industrial conditions are suitable.

3. Collections and Losses From Bad Debts.—There is no reason for any appreciable increase in the losses

from bad debts under bi-monthly billing. It is true that the average amount charged off as uncollectable is probably greater, but the total loss is kept within bounds by tightening the credit requirements and increasing the amount of the deposits taken.

The position of the collection department is really strengthened with bi-monthly billing in that each collection represents a two-month bill and the accounts are handled only half as often. Inasmuch as the customer has been extended a longer period of credit, the collection department is justified in exerting more pressure and can secure better results with fewer calls.

Some difficulty arises from the fact that the company is out of touch with its customers for a longer period of time. If a customer moves without notifying the company, the fact may not be known until two months later. Instances occur even where customers move in and out of a residence between the two meter reading dates. Such instances cause considerable confusion, and require adjustments to be made with the customers.

4. Restriction of Working Capital.—Bi-monthly billing necessarily ties up half of one month's revenue and the interest on such cash withdrawn from working capital must be considered an additional cost of this system.

5. Effect on Sales.—The sales department is inclined to feel that bi-monthly billing tends to reduce the amount of energy used and to build up a possible sales resistance to the user of ranges and appliances in that the customer is apt to consider his two-month bill as a regular monthly statement. It is to be expected that there would be a tendency for customers to forget that the bill covers a two-month's period, during the period following the transition, but we experience no serious difficulty from this source even though we operate in competition with another utility which bills on a monthly basis.

After examining the average range and lighting consumption in territories where these two companies compete for business, I am convinced that the billing period has no appreciable effect on the amount of energy consumed. I am also inclined to believe that the thought regarding range sales resistance is more imaginary than real.

6. Public Relations and Complaints.—Like most changes in policies of this sort, the public reaction to bi-monthly billing will depend upon the present status of public relations and the manner of presentation. Caution is necessary if there has been a recent change in the management or if the company is subject to public criticism. However, a company which enjoys the confidence of its customers should find it easy to explain to them that they are in effect, being allowed an additional month's credit, and are saved the inconvenience of paying their account each month. If a reduction in the rates is contemplated, this would afford an ideal opportunity to inaugurate the bi-monthly billing plan.

Unquestionably, there are a large number of people who would prefer to have their bills rendered monthly. They may operate their homes closely on a budget plan and would like to include their electric bill in each month's expenditures. On the other hand there are people who appreciate the convenience of making only six payments a year, instead of twelve and would even like to handle other small monthly charges on the same basis. We cannot satisfy all of the people, nor do I think that the sentiment is strong enough either way to have any material bearing upon the company's policy. Fortunately, the majority of the people are reasonable and can appreciate the company's desire to economize so far as is practical. If a customer is quite insistent upon paying monthly, we suggest that an average monthly payment be made on account during the unbilled month. This appears on his subsequent bill as a credit balance, leaving the net amount to be paid.

It would be misleading to contend that with half as many bills being rendered each month, there should be half as many complaints from the customers. Attention has already been called to the fact that there is a tendency for the difficulties to increase in connection with customers moving without notifying the company. To this should be added the fact that the first bill to a new tenant may cover a three or four-month period, unless a special reading is obtained.

It may also be contended that a 10 per cent increase is more noticeable on a two-month bill than on one for half the amount and that the customer would be more likely to complain about an increase of $1 on a $10 bill than he would about an increase of 50 cents on a $5 bill. This is only a conjecture which need not be given serious consideration.

I think that it is probably easier to detect errors in meter reading on a monthly basis than it is on a bi-monthly basis. To illustrate, if a customer has an average consumption of 100 kw.-hr. per month, an over or under reading of 100 kw.-hr. is easily detected on a monthly bill. On a bi-monthly bill, however, the same error represents only 50 per cent of the average bill and can be attributed to the absence of the customer or to a change in the appliances used without arousing the suspicions of the meter reader or the clerks handling the account.

Even after taking all of these adverse factors into consideration, it is still reasonable to expect that with fewer bills being handled each month, there should be fewer errors and complaints from the customers.

7. Merchandising Billing and Advertising—I doubt very much if any collection department would approve of bi-monthly billing for merchandising and installment accounts. The amount of the bill rendered is a determining factor in this instance because two monthly merchandise installments together with a two-month bill for range and lighting service would present a real collection problem. Joint merchandise and service billing is therefore impractical with bi-monthly billing.

Another objection which might be raised to bi-monthly billing is the fact that it is impossible for the sales department to circularize all customers in one month together with the bills. It would be necessary to make a special mailing at additional cost, in order reach the remaining half of the customers.

Summation

Any accountant who makes an estimate of the direct savings from bi-monthly billing will probably be surprised at the result. Estimates have been prepared by various companies which indicated a gross saving of $1 per customer per year, although in our own company, the saving does not exceed 50 cents per customer.

Taking an estimate of 50 cents per customer, I doubt if any reasonable valuation placed upon the tangible and intangible disadvantages could approach the savings which can be effected. Certainly we should be fair in our interpretation of the public relations angle and give due consideration to the sales manager's viewpoint, even though the facts are on one side against opinions on the other.

Speaking from our own standpoint, I am not yet convinced that we should spend $30,000 or more a year in order to render monthly bills to our consumers, nor do I think that any utility, operating in a territory that is adaptable to bi-monthly billing, can afford to overlook the possible economies from this source.

Even Consumption Billing

By C. R. JOHNSON*

THESE few brief remarks could hardly be termed a paper; therefore, they should be considered a "wrinkle" in customers' billing methods. With the application of any mechanical machine system to customers' records it should be remembered that unless everything is done to keep the machines in constant operation, some of the advantages would be lost which might result in not warranting the investment in such mechanical equipment. One of the many items which should receive serious consideration, is the charting of rates by schedules and demands. The ordinary method would be to calculate consumptions and print the results on charts or in books showing gross, discount (where discounts are allowed), and net amounts as well as consumptions to a given point where it is practical for the bookkeeping machine operations.

A company might have in effect many schedules and demands, making it almost impossible to compute charts which could be readily referred to by the machine operators without their being cumbersome. With

* Report presented to customers records committee.

this idea in mind, the following plan was devised and is being used satisfactorily by the Northwestern Electric Company and Portland Gas & Coke Company, Portland, as well as two large utilities in central California.

On all regular accounts, **even consumption figures,** only, are used. Wherever meter readers report even readings, no change is necessary, but where readings are reported which end in odd figures; such as, "357" or "453" the readings are advanced to even readings. It can be seen that by the use of even readings which, of course, result in even consumptions, that the number of charts required is reduced **one-half** or **50 per cent.** This is the main thought or idea of this wrinkle of billing.

There are a few exceptions which are as follows: On all billings "over" or "under" one month, the readings as reported are used, although, even in this case probably fifty per cent of such readings end in even figures. Also, where minimum bills and constant meters are concerned, the actual readings are used. On accounts that are locked or finaled, the actual readings secured are used in rendering such final bills, so that the customers are not penalized because of this method. By using even consumptions and showing kw.-hr., gross and discount amounts only (the net figure not being shown as the bookkeeping machine makes an automatic subtraction) it is possible to print about two and one-third times as many figures on each Meilicke chart or card (8x10½ in. size) as would be possible under the other system of showing all amounts and consumptions, both even and odd.

One point which probably should be mentioned is that the billings are not prefigured for the bookkeeping machine operators, except, of course, where large commercial consumers or power accounts are concerned. In other words, the machine operator registers the present and past readings in the machine at which point the machine makes an automatic subtraction, and after observing the result through the glass in the front of the machine, the operator refers to the chart for such charge and discount amounts.

As this method has only been in use for one month, I am unable to furnish exact figures as to the labor saving in dollars and cents resulting from this procedure, but I do know that when the mechanical bookkeeping machine system was installed for the Northwestern Electric Company on Feb. 1, 1929, should we have computed both odd and even consumptions, the capacity of our charts would only have been one-half of what they actually are today. Of course, where the consumption figure is beyond the chart, it is necessary for the bookkeeping machine operators to have books for such computations.

As previously stated, four large utilities on the Pacific Coast are following this plan as well as a few in the East, and other companies at the present time are considering the adoption of this method. While the idea is new and may sound radical, yet it is working out very satisfactorily for our companies, and so far, we have not encountered any difficulties resulting from the adoption of such system.

Credit Policies

By F. L. NAGEL*

IN THE pursuit of a study of public utility credit policies, two systems now in use, namely, "Courtesy Cards" as adopted by the Rocky Mountain Division of the N.E.L.A., and "Interchange of Credit Information" as it is carried on by a number of other public utilities were considered. The plan of the courtesy card system follows:

Courtesy Card Systems

Conditions—To be issued only to domestic customers in good credit standing when leaving a city. (Prompt payment of all obligations for a minimum period of 6 months necessary.)

Card to be issued with thought in mind that many utilities to which it is presented by holder will use it as basis of credit.

Card to interfere in no way with the rules and regulations of utility companies.

Purpose—Primarily to give the customer recognition of his good standing and to create in him an appreciation for the service and courtesy of the utility.

To remind the customer that good service is mutual and encourage future performance on his part.

To pass on to other utilities the good record of a customer.

To create incentive for a customer to pay all utility accounts before leaving a city.

To make possible elimination of demand for deposits from new customers when deposits are unnecessary.

Application—Card to be given or mailed customer only after payment of final bills.

To prevent possible use for credit purposes, card to be taken up by company to which it is presented.

For it to have a wide acceptance necessarily means that it must be issued under the same circumstances in all cases, as outlined above.

The success of this courtesy card depends on the care in issuance and the reception of the customer upon its presentation.

Criticism—Not having had personal experience with the operation of the courtesy card system, questionnaires were sent to twenty-two utility companies, some of them members of the Rocky Mountain Division, but all of them operating in that territory, to which replies were received from eleven companies. The information given however, was so meager as to be of no practical assistance in this study. It will be understood, therefore, that the criticisms offered are the writer's own opinions supplemented by the opinions of such members of other public utility companies with whom the subject was personally discussed.

The system as outlined contemplates the issuing of courtesy cards to customers with good credit standing when leaving the city. It is assumed that a card would also be issued to a customer not leaving the city, but closing his account with one company and applying for service to another, as well. The question presents itself, "What would be good credit standing," and by what formula would such standing be measured. The plan as outlined does not here assist us. We must assume that it is a matter of discretion and left for the person issuing the card to decide.

It is my opinion that a set formula for establishing a good credit standing cannot be set up to be followed by all members. There can be no unity of opinion as to what is good credit standing. Some companies contend that in order to be so classed, a customer should discount all his bills, while others would permit the passing of several discounts within a given period of time, and still others are of the opinion that passing discounts should not be the criterion (with reference to residence accounts) as to good or bad credit standing. For example, I am familiar with a number of customers in our company considered to be of good financial standing, honest beyond question, to whom we would not hesitate to sell merchandise amounting to thousands of dollars in value just upon their order, who, however, with regard to their domestic service accounts, would not in the ordinary use of the term be considered prompt pay. They do not discount nor pay their service bills within what we would term the delinquent time. My observation is that they prefer to let their small service accounts accumulate and to pay two or three months' bills at a time. To illustrate that all customers do not want to be troubled with these small accounts each month, I have in mind customers of our company, who rather than pay their small accounts each month, and still not to be classed as slow pay, have placed with us deposits equivalent to approximately six months' bills, from which they direct that we deduct the monthly accounts and inform them when the amount has been depleted, at which time a like deposit is again made. Surely, none of us would consider this class of customer as undesirable, or a credit risk, yet it appears to me that should such a customer, when closing his account, ask that a courtesy card be issued him, it would, according to the system as I understand it, be refused. Thus the courtesy card system would be the means of destroying good will rather than building it up, as the system is intended to do.

The courtesy card system is, in my opinion, not elastic enough and will eventually fall into the same disrepute as the old time letters of recommendation, most of which are written under pressure and do not reflect the true attitude of the person issuing or writing them. In other words, you do not get the same

* Report presented to customers records committee.

information as you would if the inquiry were made direct by the person desiring it.

Interchange of Credit Information

I am aware of no better opportunity for creating good public relations, and especially at a time when a customer is making his first contact with the company, than to offer to him the opportunity of establishing his credit with the company in the same manner as he could were he to make application for the opening of a charge account with a department store or other merchandising establishment; to permit him to establish his credit first upon his record with some other public utility, by which he had previously been served, or in the absence thereof by his record of paying his accounts elsewhere.

Public Utility Reference—The process of establishing credit by means of public utility reference is simple. When the application for service is made and the ordinary data in connection with the taking of the application is being taken, inquiry may also be made as to whether the applicant has previously been served by any other public utility company. The name of such company, the adddress and approximate time at and during which he was served should then be taken and printed forms such as the following may be used to forward to the company referred to, together with a stamped and addressed return envelope:

No.....

To.....

.....

Gentlemen:

We have an application from..... requesting the supply of service at.....Street, ...City, who refers to you as having served him at .....Street,.....City, about..... , 19.....

We should consider it a favor if you would fill in the information requested on the reverse side hereof and return it to us in the enclosed envelope. Such information will aid us in deciding whether or not to require a guarantee deposit, and will be held in confidence. We will be glad to reciprocate at any time.

Yours very truly,

Date.....

.....

(Reverse Side)

Name of Applicant.....

Served at .....

With Gas.....Electricity.....Water.....From.....19....., to .....19.....

Was guarantee deposit required?..... .....How much?.....

Were bills paid promptly?.....

Has closing bill been paid?.....

Did account require notices?.....

Remarks: .....

.....

.....

(Date) (Signed)

.....

When such information is later received back it should be an easy matter to accept or reject the account and to arrange for necessary security.

Benefits—I feel that the value of public utility reference is not fully appreciated due largely to a misunderstanding and lack of appreciation of the benefits to be derived from the system, in favor of which I might argue the following points:

First, the accommodation to the customer.

Second, the benefit derived in many instances by both the inquiring and the informing utility companies, one in receiving the prospective customers' record and the other in many instances in obtaining the address of a former customer, who may have overlooked or intentionally left a final or closing bill unpaid.

Third, the reduction of the number of cash deposits required, thereby eliminating a contact with the customer which has been the cause of much friction, and thus promoting good will.

The experience of companies who have tried this method of checking customers' credit has proved the value of the system, and I heartily recommend its adoption by those who have not yet tried it. I am sure that if all members would pursue this system that eventually a central clearing house of customers' information could be established at some central point to which lists of cut-outs and turn-ons might be sent, thus doing much to eliminate the necessity for the cash deposit, as well as assisting in collecting unpaid accounts of the class commonly called skip accounts, which class is in most companies accountable for 50 per cent of the uncollectable bills.

Commercial References

The accepting of commercial references as a means of establishing credit is commendable, it being usually safe to assume that the manner in which a person pays his ordinary household accounts reflects the manner in which he will also pay his utility accounts. It has been my experience that merchants are always willing to cooperate, and much good information may be received from them. Another method of cementing good public relations is also thus presented. It demonstrates a spirit of cooperation with the merchant and cuts down that imaginary independence often attributed to the operators of public uilities.

When references are accepted, service should be made available as soon as possible, even in advance of receiving such information. The amount lost on unscrupulous customers during the time when credit investigation is being made is negligible when contrasted with the service rendered to your customers. The following is a form designed for credit information, which I would commend to anyone desiring to adopt the system:

CREDIT INFORMATION

Utility Reference:

Company .....
City .....
Address Served .....
When Served .....

Personal References:

Name .....
Address .....
Occupation .....
Name .....
Address .....
Occupation .....

Commercial References:
(Charge Accounts)

Business House .....
Address Served .....
Business House .....
Address Served .....

Bank Reference:

Name .....

Remarks:

.....

.....

Note: This information is requested only as an aid in establishing credit.

Establishing Credit on Character and Reputation

To establish credit on character and reputation the credit man's ability to judge the character must, to a great extent, be brought into play. He must judge the customer by all the facts before him, by his business or professional connections, and his reputation in the community, as well as by his ability to liquidate promptly the obligations assumed. His conclusions must, of course, be based upon information obtained from the applicant and from other people acquainted with him. A man, whose occupation seems to be of a permanent nature assuring adequate remuneration, or if he is a professional or business man, can, with a great deal of safety, be accepted without security on a residence account. It would be well to remember that authorities estimate that 98 per cent of the people are honest and want to pay their bills promptly, and that out of that 98 per cent, 83 per cent do pay promptly.

Cash Deposits

I would recommend that the cash deposit as security for the service accounts be resorted to only when all other means, (excepting the acceptance of sureties or guarantors) of establishing the customers' credit have failed. As stated before, the demand for a cash deposit is always antagonistic to a customer and when requested the necessity therefor should be fully and diplomatically explained. The amount should be intelligently arrived at. The estimated prospective consumption should be discussed with the customer and arrived at by considering the number and kinds of appliances, and the purpose for which they are to be used. When the deposit requested amounts to a considerable sum, such as may be required to secure a large consumer in a commercial account, it often tends to work a hardship on the customer, especially when he is just embarking on a new business venture, capital

then being one of the chief essentials and often a considerable strain on the resources. Concessions may here be made to good advantage by accepting a sufficient amount to cover one or two weeks' consumption and placing the account on a weekly or semi-monthly basis, permitting the customer to increase his deposit with small weekly payments until the amount required has been paid in. It should, however, be explained to the customer that such weekly or semi-monthly arrangements are merely temporary, and made to assist him. To carry such accounts is expensive and for that reason should be discouraged except as an expedient as above outlined.

Sureties or Guarantors

The acceptance of sureties or guarantors is under the rules of most regulatory bodies optional with the utility company. I do not think that sureties or guarantors are a desirable means of establishing a customer's credit. Usually when it is necessary to force payment on an account so secured, trouble is experienced and often ill will created towards the company. Hence, public utility companies are abandoning this method of securing the payment of accounts. I, therefore, recommend that sureties or guarantors be not accepted, excepting in exceptional cases, and that when they are accepted they be informed by letter of their acceptance by the company and of the responsibility assumed by them as such surety or guarantor.

An analysis of the number of customers' accounts secured in this manner in which the surety or guarantor was later called upon to pay demonstrates that unless a thorough understanding regarding a surety's liability is had and supplemented by a letter, misunderstanding is often expressed and when forced to pay, the surety does so with a feeling of animosity towards the company. It would also be well that the surety be notified within thirty days after the delinquency of an account which he has agreed to pay.

FIXED CAPITAL COMMITTEE

The Practical Application of Fixed Capital Records for Fire Insurance*

THE purpose of this paper is to direct the attention of the public utilities to certain phases of fire insurance (as it affects them) which seem to be little understood, at least seldom considered, but which virtually determine the degree to which their properties are protected.

It is not the intent of this committee to elaborate on, or attempt to supplant, previous reports on the use of fixed capital records for insurance purposes, but rather to suggest a definite and practical modus operandi in the application of the principles of fire insurance to public utility operations.

G. H. Bourne, chairman of the insurance committee of the National Electric Light Association, in his 1926 report said,

"I want to emphasize that insurance is of sufficient importance to warrant your expert attention and a thorough understanding of the protection secured, so that when you do sustain a loss, your insurance will properly apply." (N.E.L. A. Proceedings, 1926, Vol. 83, P. 22)

Purpose of Insurance

The purpose of fire insurance is to obtain protection from financial loss in event the property of the insured suffers from fire. In exchange for a stipulated amount of money (premium) the insurance company guarantees the insured against all direct loss or damage by fire, subject to this stipulation: "The (insurance) company shall not be liable beyond the actual cash value of the property at the time any loss or damage occurs . . . . . with proper deduction for depreciation however caused . . . . . "

What Property Should be Insured

The question of what property should be covered by insurance is a matter of policy to be determined by each company, but the following tabulation indicates the various classes of property most generally accepted as requiring protection:

Buildings
Station equipment
Substation equipment
Shop equipment
Construction equipment
Transportation equipment (automobiles and trucks)
Bridges and trestles (electric railway)
Rolling stock (electric railway)
Furniture and fixtures
Stores supplies
Service equipment on customers' property (such as large transformer installations in vaults in customers' buildings).

Proper Fixed Capital Accounting and Records

Systems A Prerequisite

The prime essential necessary for accurate and complete handling of the fire insurance situation in any utility is a suitable fixed capital accounting and records system. It is impossible to make accurate and comprehensive computations of the proper amount of coverage to be placed on any structure and its contents or on any item listed in the foregoing tabulation without the availability and use of an accurate system of fixed capital accounting and recording.

Such records should contain:

1. The date of original installation, as this is essential for the determination of reproduction cost new and accrued depreciation.

2. The total cost, including all overheads, of each item of equipment in place, such costs to be segregated between the item itself and any foundations on which it may rest, in order to make proper exclusions.

3. Whether new or second-hand, as this is vital in settlement of claims of loss. (Materially affecting depreciation computation.)

4. The location, or electrical position in the station, of all equipment, wire, cable, etc., should be shown, as this information is essential for obtaining a complete list and value of apparatus which may have been completely destroyed in a fire; for example, the records of oil circuit breakers in a given station should indicate the position of each one, such as, "oil circuit breaker, 500-amp., 15,000-volt, G.E.Co., No. 381507, on Dawson Street Feeder No. 4568." All other equipment, including wire and cable, should be similarly designated by electrical position. Then, should a serious fire occur in this location, practically destroying beyond recognition some of this equipment, (which frequently happens) it is a simple matter to make up a list of all equipment in place on "Dawson Street Feeder No. 4568" at the time the fire occurred.

5. Date of rewind or replacement in kind. Another very essential item fixed capital records should contain for fire insurance purposes is the date of a "rewind" or "replacement in kind" of expensive units such as large transformers, voltage regulators, generators, motors, large lead-covered cables, etc., which may have been replaced on a maintenance or depreciation charge. In such event the fixed capital records would not normally reflect such a transaction, but from the angle of fire insurance, such data should be carefully included in those records. For example: consider a generator has been destroyed by fire and the fixed capital records show it was installed ten years prior to the fire. Assume the utility and the insurance adjuster agree on a reproduction cost new value of the machine of $50,000. Basing depreciation on a 33-1/3 year life for this unit, or 3 per cent depreciation per year, we find the sound value to be $50,000, less 30 per cent depreciation, or $35,000, which is the amount the insurance company will pay for this loss.

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* Report of fixed capital committee—L. E. Hinman, Portland Electric Power Company, chairman. E. C. Winslow, Pacific Power & Light Company, vice-chairman. Idaho Power Company: V. T. Montgomery.

Now assume another case where the fixed capital records indicate this machine was installed ten years prior to the fire completely destroying it. The adjuster agrees on the same reproduction cost new of $50,000, but in considering the accrued depreciation, the fixed capital records indicate the stator and rotor of this machine (which are admittedly the only depreciable items, obsolescence is not considered) were completely rewound new three years prior to the fire. Accrued depreciation then amounts to 3 years times 3 per cent or 9 per cent; the sound value then is $50.000 less 9 per cent (instead of 30 per cent as in the former case) or $45,500, which is the amount the insurance company should pay the insured. Thus it is seen that the record of "rewind" in this one case has saved the utility exactly $10,000.

It is obviously impossible for any person to write a complete list and assign values, from memory or familiarity, of all his personal household effects. Only a complete record of each item and its original cost or value will enable a householder to make an accurate inventory and appraisement of personal property.

The person who has suffered loss by fire or burglary in his own home will readily recall his experiences in attempting to formulate an accurate and complete appraisal of such loss. He will remember the hours of diligent thought and effort expended to make that list complete. He will also recall the fact that months after the submission of the claim, the realization came many, many times of valuable items overlooked, unthought of and omitted in that claim.

If it is impossible for a person to originate from memory a complete appraisement of a comparatively few items with which he is intimately acquainted, how much more impossible it is for him to make anything like an accurate inventory of the thousands, or even millions, of miscellaneous items which have gone into an entire property and of which he manifestly could have no knowledge or recollection.

Unless the fixed capital records do indicate such electrical positions, it will be impossible for any man or group of men, regardless of familiarity with a certain location, to sit down after a fire occurs and write out a complete and accurate list of all apparatus and equipment involved.

Fire Insurance Routine

Fire insurance routine in public utility operations consists of the following:

1. The determination of insurable items, or classes of property.
2. The computation of "present insurance value," "sound value," or amount of "coverage."
3. The placement of policies among various insurance agents.
4. In case of fire the computation and submission of claim of loss or damage.
5. The settlement of the claim.

Method of Calculating Proper Amount of Coverage

In order to answer the question, "Do you know you are protected against loss?"—it is first absolutely necessary to know you have correctly and amply "covered" every item of property insured. To determine properly such coverage requires the use of the same method that the insurance adjuster will use in computing a loss, which is, "reproduction cost new,—less depreciation." Such depreciation is based either on the actual years in service of each item destroyed or damaged; or the estimated actual accrued depreciation; or a combination of these factors. This reproduction cost new less depreciation is usually termed "present insurance value" or in insurance parlance, "sound value." At this point it is well to consider a seeming discrepancy between the method above suggested for determining "sound" or "actual cash value" at the time of a loss, and the possible opinion of legal authority, when advice is requested.

Standard policy forms read, "the company shall not be liable beyond the actual cash value of the property at the time any loss or damage occurs * * * with proper deduction for depreciation, however caused * * *" If reference be made to legal opinion concerning determination of "actual cash value," something like the following may be found:

> "Within the meaning of a policy the actual cash value of property is the price which it will bring in a fair market, after fair and reasonable efforts have been made to find the purchaser who will give the highest price. The actual cash value, then, is the fair or reasonable cash price for which the property can be sold in the market." (14 Ruling Case Law, Page 1304, Section 478).

Should such opinions be considered per se, without further qualification, it might appear that the actual cash value of all classes of property for insurance purposes is the highest price obtainable for any item in the open market at the time of a loss. Obviously this is not correct—especially if applied to electric utility properties—for it is conceivable that certain apparatus might suffer fire damage and have no market worth whatever, save scrap or junk value. This would be true for such items as generators, designed for specific and peculiar locations and conditions, and which would be of no value in any other location or for any other purpose. Such principles would afford no protection to an assured.

Therefore, in the practical application of these principles, the only time "actual cash value" is based on market price in the settlement of fire losses is when staple commodities are involved and when such staple commodities have a positive, definite daily demand in the open market. Such staples include sugar, groceries, hardware, dry goods, etc., all having definite and positive daily market value. Other items of property, such as household effects, furniture, fixtures, electrical equipment, machinery, buildings, structures, etc., have an actual cash value (for fire insurance purposes) based on reproduction cost new less depreciation, however caused, as of the date under consideration. In general, depreciation will be computed on the actual life of the property under consideration, modified, perhaps, by its actual per cent condition, or degree of maintenance afforded. This subject is given further treatment in this report under the caption, "Maximum Limits of Depreciation."

The first step in determining "present sound value" of any structure, its contents, or approximately identical units (such as automobiles, street cars, etc.) is to determine date of original construction, installation or replacement, and original cost if at all possible. This original cost (minus such exclusions as may be permitted) must then be multiplied by the proper "translation factor" (per cent increase in cost of materials in place between date of construction and present date), which result will give present reproduction cost new. This reproduction cost new figure must then be multiplied by the proper per cent condition factor (rate of depreciation multiplied by the number of years in service, subtracted from 100 per cent and that result modified, if necessary, by a consideration of the actual observed depreciation) to reduce to "present insurance or sound value."

Derivation of "Translation Factor"

Table of "Translation Factors" covering all the major classes of public utility property may be obtained from appraisal companies or consulting engineers specializing in appraisal work. These are usually quite comprehensive and can be obtained for a given geographic division of the United States. However, for the utility which does not wish to incur the expense of such service, such "translation factors" may be readily calculated, with a fair degree of accuracy, from data obtained from any reliable source.* Construction Cost Indices are available ("Engineering News Record," April 21, 1927, and September 22, 1927, are examples), which show per cent increase in costs of various materials, commodities, labor, etc., for each year subsequent to 1913, that year being usually considered the base, or 100 per cent. The following abbreviated table is indicative of "Index Numbers of Wholesale Prices" and shows relative price levels at different times compared with those of 1913.

For example, cost of steel products in 1917 was 2.31 times that of 1913. From Table I can be computed a table of "Translation Factors" as shown below, which indicates any prior year's material cost, converted to a reproduction cost percentage for any particular year under consideration. This table is necessarily abbreviated, but obviously can be worked out to any limit desired. It is obtained by dividing the index number of the year as of which reproduction cost new is to be calculated by the index numbers of the years preceding; for example, 1926 index number from Table I for

*United States Department of Labor can supply these.

TABLE I—Index numbers of wholesale prices

Year	Electric Materials (Per Cent)	Building Materials (Per Cent)	Steel Products (Per Cent)
1913	100	100	100
1914	86	92	85
1915	101	94	99
1916	104	92	105
1917	232	157	231
1918	189	172	187
1919	165	201	162
1920	195	264	192
1921	131	165	129
1922	123	169	122
1923	146	190	145
1924	136	185	133
1925	135	183	132
1926	130	177	128

steel products is 128 per cent, 1919 index number from Table I for steel products is 162 per cent; therefore, to find the "translation factor" by which steel products purchased in 1919 must be multiplied to determine reproduction cost new as of 1926, divide 128 by 162, which equals 79 per cent. This method produces the following table:

TABLE II—Translation factors for converting various previous years' material costs to 1926 reproduction cost basis

Year	Electric Materials	Building Materials	Steel Products
1913	1.30	1.77	1.28
1914	1.50	1.92	1.50
1915	1.28	1.89	1.30
1916	1.25	1.92	1.22
1917	0.56	1.12	0.55
1918	0.69	1.03	0.68
1919	0.79	0.88	0.79
1920	0.67	0.67	0.67
1921	0.99	1.07	0.99
1922	1.06	1.05	1.05
1923	0.89	0.93	0.88
1924	0.95	0.96	0.96
1925	0.96	0.97	0.97
1926	1.00	1.00	1.00

It is therefore a simple matter to determine, for fire insurance purposes, the cost to reproduce new in 1926 any steel product item which cost, say $1,200 in 1919, by multiplying $1,200 by .79, which equals $948. As stated previously, this reproduction cost new figure of $948 must be reduced to "present insurance value" by deducting the actual accrued depreciation, or, conversely, by multiplying by the percent condition of the equipment, which gives the amount to insure.

Rate of Depreciation

The proper rate of depreciation to be applied to various classes of insurable property and equipment is a vital one, for this, too, determines the degree to which a certain property is "covered" or protected. For example, assume the contents of a certain generating station, installed seven years ago, to have a present reproduction cost new of $1,000,000; and suppose, for placement of insurance, a composite life of such contents to be twenty-five years, which life estimate has been somewhat carelessly made because of its seeming unimportance, it then would be determined to insure that property for $720,000, based on the following computation: reproduction cost new less actual depreciation equals present insurance value, or $1,000,000 x [100 percent—(4 per cent per year x 7 years)]* = $720,000, based on a "guess" of twenty-five year life, or 4 per cent depreciation per year. Assume further that a serious fire occurs, after insuring for $720,000, and practically destroys the entire plant, and it becomes necessary to submit claim of loss. The fixed capital records of that station, which should have been accurately maintained are referred to, and the reproduction cost new of the destroyed property is found to be $1,000,000. Inasmuch as the claim should be as accurate as possible for the insured's own good, and in view of the fact it must be "signed and sworn to by the insured" (this clause contained in all standard policy forms) the question of "rate of depreciation" is carefully investigated and found to be 3 per cent based on a composite life of 33⅓ years; applying the formula, $1,000,000 x [100—(3x7)]=$790,000, which is the amount of the loss suffered. To the insured's chagrin, it is found the policies amount to but $720,000, which means the utility must "hold the sack" and suffer an actual monetary loss of $70,000, all because of a seemingly unimportant factor, 4 per cent instead of 3 per cent depreciation. So that apparently difference of 1 per cent in rate of depreciation has resulted in an actual loss of 8.8 per cent. Just what is the proper rate of depreciation for various classes of property is largely a matter of experience and common practice. In order to preclude possible serious misunderstandings with insurance representatives, such factors should first be discused with the Board of Fire Underwriters having jurisdiction.

*Modified, if necessary, by consideration of the actual physical condition of insurable items.

Maximum Limit of Depreciation

For fire insurance computations there is a maximum limit of depreciation to be applied, for the obvious reason that otherwise, under certain circumstances, property and equipment may depreciate theoretically to zero value. For example: a certain utility has been ordered by its regulatory commission several years before to base accruals for depreciation on its street cars on an estimated length of life of eighteen years. This company, in order to be consistent with that practice, had been applying that same rate of depreciation (5.55 per cent per year) to its rolling stock for purpose of computing fire insurance sound values. It suddenly was discovered that certain cars which had been in use over 20 years had depreciated to zero value theoretically, but, due to constant maintenance, were virtually as good as new: therefore, the officials decided that in such cases no greater depreciation than 66⅔ per cent was to be applied for insurance purposes, regardless of the actual age of that equipment. The determination of such maximum limits is purely a matter of policy and should be decided by each utility, with the expressed approval in all cases of the Insurance Rating Bureau or Board of Fire Underwriters having jurisdiction. Such approval will preclude any possible controversy in submission of values or claims of loss.

Recomputation of Values Upon Renewals of Policies

It is readily apparent that insurance values should be recomputed at least as often as a policy is renewed as the "translation factor" may have changed meanwhile, and obviously the "depreciation factor" will increase each year until its maximum is reached. Any large additions to, or removals from insured properties, during the life of a policy warrants a recomputation of values to provide either increased coverage or refund on premiums paid.

Exclusions

Certain exclusions should be made from original values or costs, before beginning the computation of "present insurance value" of plant or equipment, representing items which suffer no loss or damage in event of fire. Some of the more apparent exclusions are: building excavation and foundations; machine foundations; cofferdams; subways; conduit and piping buried underground or in masses of concrete, etc.; steel columns and concrete slabs or mats, if so located that no possible damage from fire can result; architects' fees, plans, etc., if reasonably certain such costs will not be reincurred in event of fire; water and steam turbines if not subject to damage from fire or falling timbers or structures.

Any item may be omitted if specifically excluded and so stated, but of course no recovery can then be subsequently made for loss or damage to such item.

Method of Determination of Loss

The proper method of procedure in calculating a loss after a fire, is identically the same as computing the amount to insure for; or, in other words, the same method as used to determine "present sound value." A complete and accurate list must be made of all equipment, apparatus, wire, cable, and miscellaneous material damaged or destroyed. The list should be made in the field and then checked with the Fixed Capital Records to make certain the inclusion of items which may have been so completely destroyed as to leave no visible evidence of their existence. The following facts are vital in this regard and should be remembered: an insurance adjuster, in adjusting a claim of loss, will minutely scrutinize every item in such statement: he will ask

the date of original installation of every item in that claim; he will wish to know the original cost in place of these items; and if any piece of apparatus, or any wire and cable has been replaced after a fire with second-hand or "used" material, he should know that; and the utility man, looking after the interests of the insured, should see to it that no deduction for depreciation is made by the adjuster on such "used" materials, for the obvious reason that the insured has already made such deduction in submitting second-hand values in the claim of loss.

General Considerations

There are certain phases of this general subject of fire insurance that are worthy of special consideration and which, if put into practice, will return handsome dividends in terms of real dollars.

When the methods herein suggested are put into effect, it is essential that some one individual be made responsible for their proper application. It may not be necessary for him to give all his time to this work, but it is obviously of advantage to obtain centralized control. He should receive prompt notification from all operating departments of any additions or retirements affecting insurable items. (A proper fixed capital records system will automatically accomplish this.) This will enable him to increase, decrease, or cancel any policy as may be required. He may or may not be authorized to make actual placement of policies and settlements of losses, but it should be his duty, and his only, to make all computations and reports affecting fire insurance, and transmit same to the proper officer for final disposition.

Field Survey

He should have personal knowledge of the physical characteristics of all his company's insurable property in order to make certain decisions intelligently. This means his personal visitation to all plants and properties periodically, that he may have a mental picture of major details, which is absolutely essential to an intelligent execution of placement of coverage, exclusion of non-insurable items and actual equipment affected in event of loss. Such a survey will invariably reveal vital inconsistencies, such as over-insurance on some properties, under-insurance on others, none at all on some, and there have been cases of insurance being carried on properties previously retired or disposed of.

The committee is familar with the following case resulting from an actual field survey: before the survey was made, a certain utility was carrying a total of $8,920,215 insurance on its properties, for which it paid annual premiums amounting to $24,911.90, at an average annual rate of $0.28. As a result of the data obtained by the survey, the utility was enabled to increase its insurance coverage to $9,548,898, at an annual premium cost of $24,239.90 with an average annual rate of $0.253. The net result was an increase in coverage of $621,674, with a corresponding annual saving in premium cost of $672.09. The cost of making the survey and revising the schedules was $822.68. Actual cash refunds representing cancellations and rate reductions were received amounting to approximately $2,500. Was the survey worth its cost?

Effect of Reduced Rate Average Clause

If insuring under a reduced rate average clause especial care should be exercised to determine, beyond a reasonable doubt, the actual present insurance (sound) values. The greater sin in this case is "under insurance" rather than "over insurance," as will be pointed out. In consideration of the reduced rate at which a policy may be written under this form, the assured becomes a "co-insurer" to the extent stipulated therein and thereby assumes his certain portion of any partial loss(in event of a total loss, the reduced rate average clause becomes inoperative and the insurance company pays the face value of the policy), so it is obviously to the insured's best interest to see that he is sufficiently "covered" in order to reduce the possible per cent of loss which he may be compelled to assume in event of fire. The following illustrates this: the reduced rate average clause reads, "In consideration of the reduced rate at which, and the form under which, this policy is written, it is expressly stipulated and made a condition of the contract that, in event of loss, this company shall be liable for **no greater proportion thereof than the amount hereby insured bears to**—per cent (60, 70, 80, or 90 per cent, as the case may be) **of the actual value of the property described herein** at the time when such loss shall happen.* * * * In event that the aggregate claim for any loss is both less than $5,000 and less than 2 per cent of the total amount of insurance upon the property described herein at the time such loss occurs, no special inventory or appraisement of the undamaged property shall be required." Assuming then, that there has been suffered a $45,000 loss on a property which has been previously insured under a 90-per-cent reduced rate average clause for $70,000 (the $70,000 being 90 per cent of $77,800 which was estimated to be about the sound value of the property). The insurance adjuster then requests a special inventory and appraisement of the undamaged property which cannot be estimated but must be carefully prepared and which indicates a sound value of $55,000. The adjuster then adds this $55,000 to the claim of loss, $45,000, and finds the "actual value" of the property at the time of loss to be $100,000. He then determines that the insured should have carried 90 per cent of $100,000 or $90,000. However, the utility had insured for $70,000, so, applying the italicized portion of the reduced rate average clause quoted above, he finds his insurance company is liable for no greater proportion than the amount insured ($70,000) bears to 90 per cent of the **actual** value ($100,000) of the property when the loss occurred, or in other words, his company is liable for $70,000 divided by .90 × $100,000, multiplied by $45,000, which equals $35,000. Therefore, the utility is forced to accept $35,000 for a $45,000 loss, all because someone may have felt unwarranted in spending a little time or money to obtain accuracy in the amount insured for.

"Direct Loss" Defined

To those having had a limited experience in fire insurance matters the following will be of interest and is very important from the standpoint of the insured.

Standard policies provide that the insurance company insures against "all direct loss or damage by fire." The question is, what constitutes a direct loss or damage by fire? Direct loss has been interpreted by the courts to mean any loss, such that there is a direct chain of events between fire as the originating agency and ultimate property damage. It is not necessary that there be actual destruction of insured property by the blaze itself, in order that the loss may follow, under the terms of the insurance contracts. There are many cases on record where fire occurring in one part of a building caused trouble in a removed part of that building, resulting in damage to property and equipment removed somewhat from the actual scene of the blaze. For example, a case is on record where a small fire in a waste basket burned the insulation from adjacent electric wires, resulting in a short circuit at that point, which, in turn, caused serious damage to other electrical equipment in an entirely different part of the building. The case was taken into the courts for settlement, who held that, in this case, there was within the terms of the insurance contract a "direct loss" by fire and the insurance company was obliged to pay the loss. Another case is on record where mechanical damage was done some distance from the fire, and the insurance company was declared liable by the courts. (See "Joyce on Insurance," second edition, volume 4, page 4,605, section 2,761.) Damage caused by water or falling walls resulting from the fire also constitutes a direct loss or damage within the terms of the contract, and such loss is recoverable.

Record of Insurance Computations

A record should be kept of all calculations involved in obtaining "present insurance values" and the forms illustrated here indicate a method which has been found quite satisfactory and also provides a ready means of making subsequent or revised studies. Form "A" is 5 in. wide x 8¼ in. long, loose-leaf, on light stock, and forms the permanent base of all subsequent computations. This particular form is for building; others of a similar nature are adapted for contents, electrical equipment, etc. It will be noted that this form shows certain vital data including the "original" cost and cost of subsequent additions to the value of that particular structure. It will be noted also that the value of "items excluded" is automatically cared for under "original cost," but the items should be listed under "exclusions." Form "B" is the work sheet which is in-

TABLE III—Northern Substation Building.
5-10-26

Form "A"		Form "B"		
Location: Lots 1 & 2, B 10, Northern Hill Addition. Description: Brick section 32'x53'x19' Concrete Add. 35'x53'x36' high Year Built: 1908. Concrete Add. 1924 Exclusions:	Orig. Cost	(1913 Cost Index = 100%) × Increased Mtl. Cost	(Depreciation) or × % Condition	Present Insurance = Value
Excavations	$ 200			
Foundations	650			
Concrete Roof Slab	200			
Buried Piping and Conduits	375			
		Per Cent	Per Cent	
Floors: Concrete	$ 298	177	100 — (18 yrs. × 2%) = 64*	$ 337
Walls and Masonry	1,100	177	100 — (18 yrs. × 2%) = 64	1,246
Steel and Iron Work	330	130	100 — (18 yrs. × 2%) = 64	275
Carpentry	128	177	100 — (18 yrs. × 2%) = 64	145
Roofing, Wood, Tar and Gravel	230	177	100 — (18 yrs. × 2%) = 64	260
1914 Additions	198	138	100 — (12 yrs. × 2%) = 76*	207
1918 Additions	630	157	100 — (8 yrs. × 2%) = 84	830
1920 Additions	730	67	100 — (6 yrs. × 2%) = 88	430
1921 Additions	436	107	100 — (5 yrs. × 2%) = 90	420
1922 Additions (Storage Bat. Room)	800	105	100 — (4 yrs. × 2%) = 92	770
1923 Additions	500	93	100 — (3 yrs. × 2%) = 94	435
1924 Additions (Concrete Add.)	10,000	96	100 — (2 yrs. × 2%) = 96	9,200
			Present Insurance Value	$14,555

*Note.—These percentages to be modified if necessary, to represent the actual physical condition of insurable items.

serted in a loose-leaf folder under Form "A." It is 8½ in. wide x 8½ in. long and provides a ready means of making the necessary calculations as well as a permanent record thereof. When, at a later date, it becomes necessary to correct the data by applying new "translation" and "depreciation" factors, it is a simple matter to insert another Form "B" under Form "A," place the corrected factors in the columns provided and proceed with the new computation. It will be readily apparent that under such a scheme very little time is required to derive "present insurance value" for any structure, contents, or group. Table III shows these forms.

PURCHASING AND STOREROOM COMMITTEE

Purchasing and Storeroom Practice*

THE purchasing and storeroom committee held one meeting in Salt Lake City during the association year. The work of the committee last year resulted in an excellent discussion of purchasing methods and purchasing department records, prepared by A. D. Smith, purchasing agent of the Utah Power & Light Company. Inasmuch as the purchasing problems were taken up by the committee last year, this year's committee decided to discuss and review storeroom methods, giving attention to the results of storeroom accounting which involve preparation of statistics, classification of accounts and reconciliations of book balances and inventories rather than a discussion of routine methods of store-keeping, which subject has been covered a great many times in the work of various committees, not only in this section, but in other geographic sections and in the national committee.

In order to simplify the work of the committee, a subject was assigned to each member for study and the results of these studies are consolidated in the general report of the purchasing and storeroom committee.

Classification of Material and Supplies

The investment in material and supplies of a utility is an asset which should be controlled in as much detail as possible with the idea of keeping the amount invested to the minimum. It is an easy matter to carry large stocks of material which anticipate the needs of the various departments for long periods of time and for every conceivable emergency. If such a plan is followed it not only requires large investments in material, but also investments in storerooms to take care of such material adequately and the expense of operating stores and the cost of storeroom accounting is increased. In present day management it is unnecessary to carry large stocks of material because present methods of transportation and communication are such that deliveries may be made from far distant points by freight without additional charges, within probably a maximum of one week's time. Efficient methods of communication and transportation allow us to carry the minimum quantities of material and supplies. However, such minimum cannot be obtained without some adequate method of control whereby we may ascertain from the accounts whether or not we are overstocked on various items of material. In order to obtain a check of the investment in material and stores, some method of classification of this investment should be followed. This may be obtained by determining a classification which is applicable to utility business. Such a classification should, if possible, reflect the needs of the various departments which require any quantity of material and supplies in their operations. It is the opinion of the committee that possibly the best general division would be between the following groups:

Construction and Maintenance Material—In this group should be classified the material required by the distribution department and possibly the transmission department, depending upon the operation organization of the company. The material classified under this heading should include material and supplies which are necessary for the efficient operation of transmission lines and distribution systems including also supplies necessary for extensions which are constructed to take on new customers in the ordinary operation of the business. Any large extensions which will be constructed will necessarily involve purchase of a special quantity of material. Any special apparatus and requirements for such work are of a special nature and not ordinarily carried in the general stock of material and supplies.

Merchandise and Jobbing Sales—A great majority of utilities are engaged in the sale of current consuming devices which are important in load building work. It is usually the case that merchandise sales are of sufficient importance to have an organization employed primarily for the sale of such merchandise and generally result in what might be termed "Merchandise Sales Department." The storing and handling of resale material is a phase of the business which has entirely different problems as compared with the operations in connection with the sale and delivery of electric current. Merchandise sales must necessarily be competitive with other merchandising firms engaged in the same line of business, and as

* Report of purchasing and storeroom committee—**R. H. Jones,** Utah Power & Light Company, chairman. **L. A. Seare,** Utah Power & Light Company, vice-chairman. **Idaho Power Company:** Alan Ashton, I. E. Joslyn. **Utah Power & Light Company:** H. Mann. **Utah Power & Traction Company:** V. L. Halliday.

the success of a merchandising business depends largely upon the rapidity of the turn-over and elimination of slow moving stock, therefore it is advisable that a separate grouping should be maintained for all resale material.

Where there is some overlappnig between merchandising department and distribution departments, the materials which are used both for resale and operation and maintenance, an arbitrary rule must be followed classifying the particular item of material in one of the above groups. For example, a great majority of lamps are stored for resale, but, it is often the case that companies, through the medium of their rates, furnish renewals for signs, window lighting, etc., and it follows that lamps are stored both for resale and for the operation and maintenance of the utility. When such conditions are encountered, lamps should be classified as resale material, since possibly the greatest quantities are used for this purpose. That is, we are trying to point out that the general use to which an item of material is put should determine its classification.

Fuel Stores—We have outlined above that the major quantities of materials stored are used in the merchandise department and the transmission and distribution departments, or rather for the delivery of energy to the customer. The production department, which may be either steam, hydro or possibly internal combustion, does not require any great quantities of material stored, with the exception of fuel. Of course there is no fuel required for hydro operation, but there is a great necessity for storing coal, oil, etc., for steam and internal combustion operations. The quantity and value of fuels used are important in determining the cost of production. The quantity of such items, which are carried in storage, depends largely on the location of the plant with reference to the source of supply. However, such large quantities of fuel are used in the normal operations of a power plant that we believe it is important to carry a separate segregation of this class of material so that it may be more readily controlled, furnishing a medium through which may be obtained the cost of production and other important statistics which enter not only into the storing of the fuel, but also into the production operations of the company.

General or Miscellaneous—In the operation of any utility it is sometimes found that certain material must be carried in stock for which there is practically no method of determining control as to turnover, etc., and which does not pertain directly to the various departments which we have classified above. We refer here particularly to spare parts which are very often carried in stores accounts. By spare parts we mean some particular apparatus or part of an apparatus which is carried in stock to replace some specific item which cannot be used for any other purpose. This very often occurs in hydro-electric production and the investment in turbine or generator parts is well warranted, for in case of break-down if the spare parts were not on hand it would involve a great deal more loss than the cost of carrying such items in stores. Of course opinions vary as to the methods of accounting for spare parts. Some companies advocate capitalizing them, as a spare part is just as much a necessity as the installation that is producing energy. However, if such spare parts are included in stores, they should be put in a separate grouping as they are purchased for a special purpose which is not in any way related to the ordinary storing of material and supplies that are carried in stores for resale or general use.

The operations of companies vary in their requirements and while we are pointing out the necessity for grouping spare parts under general and miscellaneous, no doubt other items should be given grouping under this general heading. Our suggestion, therefore, is that the heading "General and Miscellaneous" should be used as a general classification and that "Spare Parts" be one group under this classification and other groups added as the operations of a particular company require.

The above classification which separates all material and supplies stored in the four general groups, we think, is the first division that should be made of the material and supplies account. This classification is of such general nature that it will apply to the operations of practically any utility and while we are defining this classification as applied to an electric utility, we believe that the same general classification can be applied to gas or other utility operations. The requirements of an individual company for further classification is determined largely by its location to the territory it serves and its plan of organization. A company operating over a large territory will have a greater investment in material and supplies than one operating in one good sized city or town, but this same company operating in a large territory may find it necessary to store its material and supplies in 40 or 50 locations whereas the company operating in one large town will store all its material in one warehouse. It can readily be seen that the company that has its material stored in numerous warehouses may not find it necessary to have any further refinement of its material and supplies classification other than the headings outlined above, as such additional classification would no doubt prove rather expensive when applied to a number of small storerooms and the organization of such small storerooms would not be adequate to maintain the clerical work necessary for more refined classification.

It is the opinion of the committee that further classification than the general headings outlined above should be determined by the needs of the respective companies. It was the intention of this committee to submit in this report, classifications used by various companies which would show various degrees of refinement. However, at this time this committee has been unable to obtain such classifications and we suggest further study along these lines by the purchasing and Storeroom Committee in the future.

Storeroom Statistics—The necessity for storeroom statistics depends largely upon the management of companies operating storerooms. The subject of storeroom statistics is so inter-related with storeroom classification that it is almost impossible to discuss statistical requirements without first determining the storeroom classification.

The statistics interesting to the management of the company are, no doubt, first as to various quantities of material and the necessity for maintaining such quantities, and, second, the rate of turn-over in the various classes of material. Additional statistics, of course, can be prepared showing comparisons within the company and various other interesting details. The preparation of statistics of this nature will no doubt enable the management of a company to determine without personal inspection, whether or not storerooms are being operated in the most efficient manner.

The subject is rather difficult to define because the requirements for such statistics depend greatly upon the organization and management of a particular company. Included, however, in this subject is the classification of stores and expense, as statistics can not be adequately furnished unless some predetermined classification is assigned to the expense of operating storerooms.

The committee suggests the following subdivisions in stores expense:

1. Purchasing department expense, including all salaries and expense of purchasing department.
2. Storeroom rent when premises are not owned by the operating company.
3. Salaries of storekeeper and assistants.
4. Miscellaneous supplies and expense including freight between storerooms and all expense incident to operating a particular storeroom.

Reconcilement of Stores Record With Control Acounts

There is considerable variation among utilities in the method used in reconciling the stores records in the field with the general office control account for materials and supplies. Usually the local office keeps a record of this kind, number and cost of each unit of supplies, noting receipts and issues on this record. No attempt is made to keep the total cost of the material on hand in balance with the general ledger account each month, but an annual or semi-annual inventory is taken for this purpose. At this time the local records are corrected to agree with stock on hand and any shrinkage is charged off to the appropriate account.

We are outlining one method being used, however, by which both local and general ledger records are reconciled at each month's closing. Under this system, as is usual in all companies, materials sold or used for company purposes are reported to the general office

on appropriate forms; also receipts and transfers of material are so reported. Copies of invoices for material purchased are transmitted from the general office to the local stores points. The local office record contains the kind, number, unit and total cost for each type of material on hand. Receipts, issues and transfers are posted up to a fixed closing date each month, after which a balance in number of items and total cost is recorded. As a subsidiary to the stores ledger there is also a distribution ledger to which is posted the amount being charged to any particular account; fixed capital, operation or maintenance, etc., a separate sheet being used for each account. This record is also closed and balanced for each month coincidentally with the stores ledger. The distribution ledger record is totaled for each month only and no cumulative figure is carried.

After all postings for the month are entered in both distribution and stores ledgers, the stores clerk proceeds to make up a reconcilement report for transmittal to the general office. This reconcilement shows first, the charges to the various accounts as shown by the distribution ledger. This is set up in voucher form and shows the distribution of the cost of all materials issued for the month. This is followed by a like form, only the entries are in red and cover materials returned to stores, showing amount and accounts credited. Following this is a detailed record of material sent to the other stores points and showing the memorandum of transfer number and amount. Transfers received during the month are also shown in detail. However, for transfers received, the date and place from which the material is received is shown, together with the number of the transfer memorandum and the amount. Invoices taken into account during the month are listed in detail, showing the invoice number, date, from whom purchased, our order number and the amount, freight and express being shown as a separate figure. The totals from these various reconcilement forms are brought together as follows:

Stores ledger balance previous month	_____
Invoice taken into account	_____
Transfers taken into account	_____
Stores returned	_____
Stores issued (red)	_____
Transfers out (red)	_____
Stores ledger balance current month	_____

This later is followed by another group of figures showing the amount of stores by stores classification, resale material, line hardware, copper wire, etc.

This reconcilement enables the general office to verify its figure each month as it pertains to each stores point. A reconcilement sheet is set up and material in transit, etc., is taken into consideration and the balance set up by each stores reconcilement report is proven.

The local stores clerk does not attempt to verify his stores ledger balance with the reconcilement until after the first of each month at some off-peak period of office work. An annual inventory is taken to verify stores records, at which time the shrinkage is charged off.

STATISTICS COMMITTEE

Presenting Monthly Statistical Data to an Operating Executive*

SELECTION of the subject, "Mode of Presenting Monthly Statistical Data to an Electric Operating Utility Executive" and making it the object of serious study was determined only after the following two questions were completely answered: How can the statistics committee function as a service organization to executives through the association work? and, What subject in the realm of statistical thought, if carefully developed and organized, will be most practical and useful to electric utility operating executives?

The aim throughout the entire study is to suggest practical and useful modes of statistical presentation for different types of data. Nevertheless, the committee has taken advantage of the opportunity to illustrate in graphical and tabular form the subjects most used by the utility executive. The data used in the different charts were gathered from various sources and do not represent the operating conditions of any particular utility. The committee limited its work to the method and form of presenting statistical data and the subject matter presented was used simply for illustrative purposes.

There are presented with this report, ten charts. Each one illustrates a method of graphic analysis which is believed to be adequate for the type of subject matter treated. The charts are presented in a logical order from an operating executive's viewpoint. A description accompanies each chart.

In this report, the committee has limited itself to a bare minimum of suggested modes of presentation.

Chart A—The "Graphic Outlook"

This graph gives the major changes in the current month and the twelve months ending currently, compared with similar periods of the previous year.

The subjects are arranged in three groups. In the first group, changes in gross revenue, expense, net revenue, estimated revenue from new business and number of consumers added are shown. The second group shows the changes in the volume of kw.-hr. sales by segregated groups and helps to explain increases or decreases in the first group. The third group includes external factors which show what changes occurred in general business conditions. Trends in conditions outside of the utility business help explain increases or decreases in the first and second groups.

Additional subjects may be added to this graphic outlook in any of the groups, depending entirely on whether the factor is relatively important to a given utility.

Chart B—Analysis of Revenues

This chart deals with gross revenue, comparing estimated and actual revenues by months and moving annual totals with previous years. Similar charts elaborating the sources of revenue, such as industrial, commercial, residential, farm and miscellaneous revenue can be used advantageously to lead up to chart B, which summarizes all revenue.

Chart C—Analysis of Expense

There are three charts in group C as follows:

C-1. This chart deals with total expense, actual and estimated, compared with previous periods. The form used is identical with that used in chart B and can be further used in analyzing all subdivisions of expense.

C-2. This chart shows the ratios of various expenses to total expense. In presenting a chart form, permitting the analysis of various types of expense such as production, transmission, etc., two sheets are used, one facing the other. On the left the tabular detail is shown. On the right, the chart shows a percentage analysis, item by item, making up the total expense. On the extreme right of the chart, the annual average ratios are shown.

C-3. This chart shows stores' movements, showing the amount purchased, issued, balance and comparison with previous years. The yearly average as at the end of each month as well as the monthly balance is shown. This is a ratio chart, used when the data are to be compared relatively. The tabular arrangement is in form similar to previous charts.

Chart D—Analysis of Kw.-Hr. Production and Sales

There are three charts in group D as follows:

D-1. This chart shows the total amount of power generated and purchased. The comparative features

* Report of statistics committee—**Bjorn Gadeholt**, Northwestern Electric Company, chairman. **R. W. Miller**, Idaho Power Company, vice-chairman. **Northwestern Electric Company:** Paul W. Ager. **Puget Sound Power & Light Company:** L. J. Pierce.

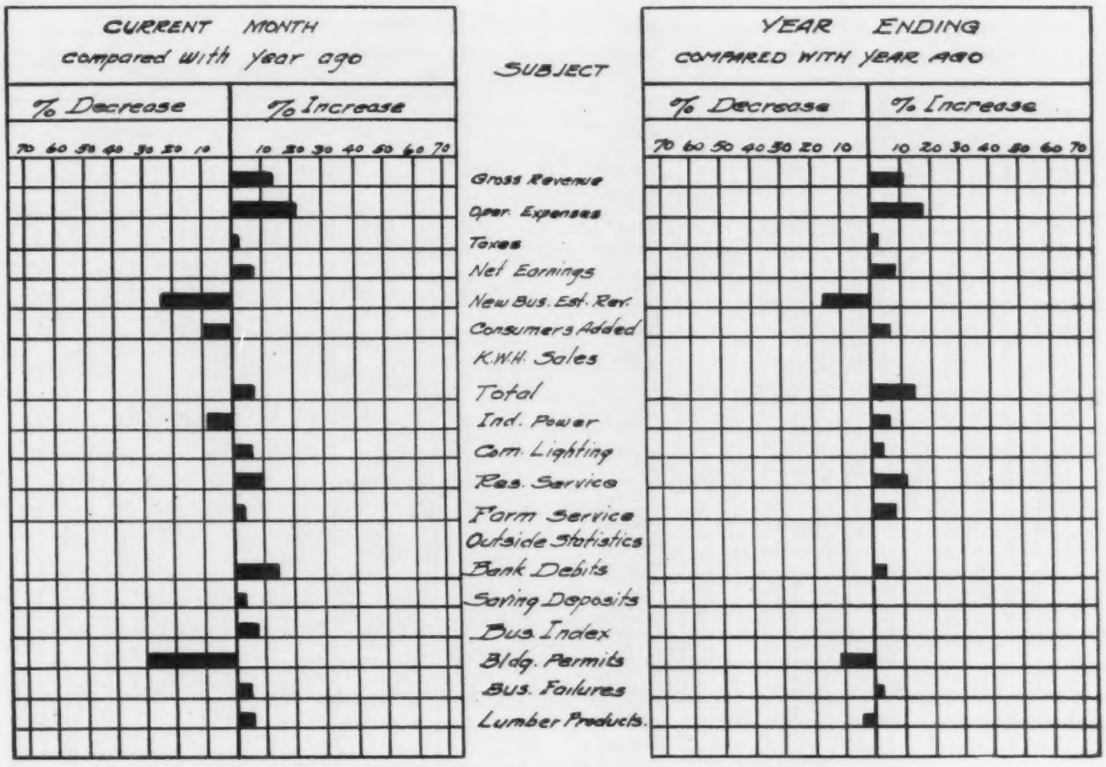


Fig. 1. Chart A. Graphic outlook for March, 1929. A summary chart.

ANALYSIS of REVENUES

Month	1927 Actual Revenue	1928 Estimated Revenue	1928 Actual Revenue	1928 Increase Over last year	1929 Estimated Revenue	1929 Actual Revenue	1929 Increase over last year
January	$ 194 782	$ 187 080	$ 196 673	4 971	$ 199 000	$ 200 098	$ 3 425
12 Mo.	$ 2 009 444	$ 2 046 721	$ 2 117 945	18 301	$ 2 322 448	$ 2 18 349	100 304
February	177 613	185 420	187 384	9 771	198 321	199 603	12 218
12 Mo.	$ 2 021 678	$ 2 059 633	$ 2 127 716	106 118	$ 2 335 309	$ 2 30 467	102 751
March	179 565	182 361	187 727	8 162	197 422	197 461	9 736
12 Mo.	$ 2 033 521	$ 2 074 621	$ 2 135 378	103 537	$ 2 249 990	$ 2 240 201	116 523
April	176 467	180 102	181 144	4 677	196 634		
12 Mo.	$ 2 043 061	$ 2 087 063	$ 2 140 588	97 496	$ 2 266 512		
May	171 256	180 009	180 255	8 999	190 220		
12 Mo.	$ 2 058 181	$ 2 105 730	$ 2 149 554	94 373	$ 2 274 733		
June	167 978	179 603	178 697	10 722	189 321		
12 Mo.	$ 2 065 001	$ 2 119 373	$ 2 160 276	94 863	$ 2 286 501		
July	161 638	176 818	173 646	12 008	188 719		
12 Mo.	$ 2 073 804	$ 2 153 419	$ 2 172 284	98 980	$ 2 292 439		
August	162 667	177 699	173 952	11 305	180 936		
12 Mo.	$ 2 083 263	$ 2 180 127	$ 2 183 589	101 326	$ 2 299 256		
September	169 414	180 786	178 346	8 932	188 291		
12 Mo.	$ 2 093 158	$ 2 192 607	$ 2 192 521	99 363	$ 2 306 761		
October	177 734	186 732	186 000	8 266	193 413		
12 Mo.	$ 2 100 157	$ 2 239 068	$ 2 200 787	100 628	$ 2 313 465		
November	182 977	196 388	193 000	10 923	198 728		
12 Mo.	$ 2 106 235	$ 2 231 073	$ 2 211 710	108 475	$ 2 317 535		
December	196 988	199 308	198 000	3 015	201 233		
12 Mo.	$ 2 113 074	$ 2 210 653	$ 2 216 726	101 660	$ 2 319 507		

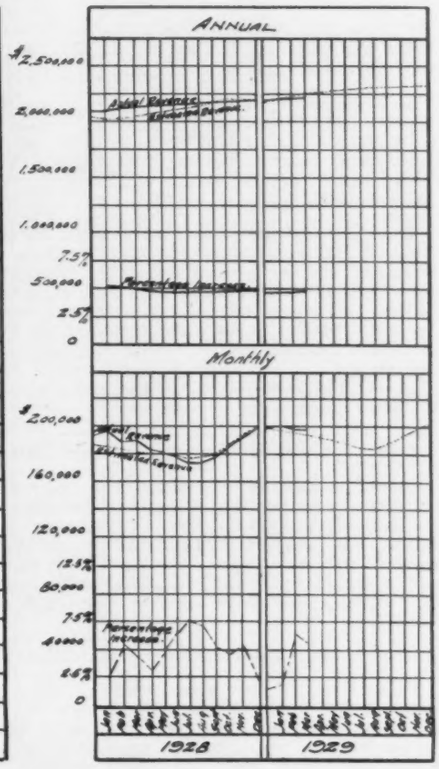


Fig. 2. Chart B. Analysis of revenues.

ANALYSIS of EXPENSES

C-1 TOTAL OPERATING EXPENSES

Month	1927	1928			1929		
	Actual Expense	Estimated Expense	Actual Expenses	Increase Over last Year	Estimated Expenses	Actual Expenses	Increase Over last Year
January	$ 117 955	$ 115 902	$ 117 560	$ 375 0.3%	$ 117 029	119 000	1 440 1.2%
12 Mo.	1 287 719	1 300 294	1 337 503	49 783 3.9	1 375 990	1 358 764	21 262 1.6
February	110 707	114 965	113 087	2 380 2.1	116 201	123 000	9 913 8.8
12 Mo.	1 294 322	1 308 921	1 339 882	45 560 3.5	1 377 223	1 368 677	28 795 2.1
March	116 152	114 705	114 916	766 0.7	115 307	116 000	1 084 .9
12 Mo.	1 301 539	1 317 263	1 340 641	39 117 3.0	1 377 825	1 369 761	29 115 2.2
April	111 589	114 070	112 173	644 0.6	114 508		
12 Mo.	1 306 633	1 325 075	1 341 260	38 628 2.9	1 378 269		
May	110 661	112 507	112 482	2 421 2.2	114 136		
12 Mo.	1 311 651	1 332 107	1 343 681	32 130 2.4	1 379 892		
June	108 808	111 379	111 126	2 318 2.1	116 291		
12 Mo.	1 318 316	1 339 963	1 345 997	27 683 2.1	1 382 844		
July	107 658	111 977	111 386	3 728 3.5	116 607		
12 Mo.	1 321 966	1 344 228	1 349 725	27 759 2.1	1 385 430		
August	109 096	112 624	112 142	3 046 2.8	114 915		
12 Mo.	1 327 719	1 349 769	1 352 771	25 052 1.9	1 387 725		
September	103 517	114 671	110 579	2 962 2.9	115 016		
12 Mo.	1 332 447	1 351 123	1 354 633	22 786 1.7	1 388 070		
October	112 474	115 390	114 000	1 526 1.4	116 104		
12 Mo.	1 336 866	1 357 963	1 357 159	21 993 1.6	1 388 780		
November	111 963	117 763	115 000	3 037 2.8	118 972		
12 Mo.	1 336 973	1 368 721	1 360 296	23 323 1.7	1 389 789		
December	116 048	118 703	113 000	- 3 048 -2.7	119 730		
12 Mo.	1 337 997	1 374 269	1 367 324	19 427 1.5	1 390 816		

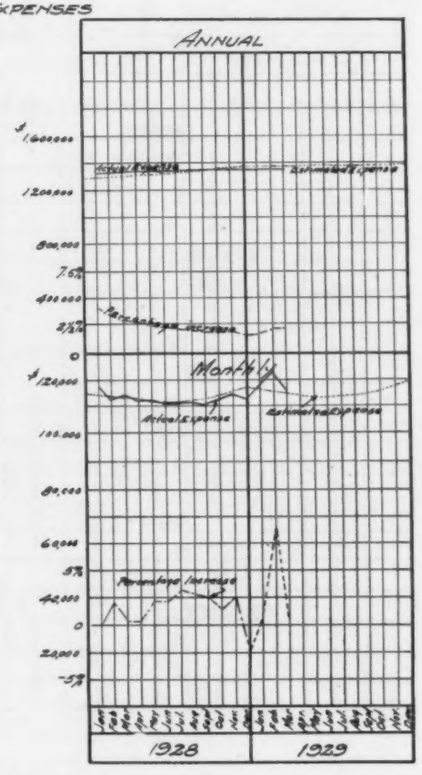


Fig. 3. Chart C-1. Analysis of total operating expenses.

are most valuable. On the extreme right, the curves show cumulative total kw.hr. by months as well as moving annual totals.

D-2. A chart showing the ratio of hydro to steam power, by months and by years. The figures are in columns paralleling the curves illustrating the trends. One thus quickly catches the significant meanings. This feature is one worth emphasizing in statistical presentation.

D-3. These three individual charts are samples of what might be grouped together to show clearly the trend of industrial activity. The two lower charts show kw.-hr. consumption by large consumer groups. (Flour and cereal mills and lumber mills are used here for illustration.) Above, the index number series permits of a lucid survey of volume of kw.-hr. sales in any company, measured against the volume of activity such as shown by the Electrical World index or other indices of industrial activity.

Chart E—Analysis of Unit Costs

There is used in this chart a graphic form which permits one to see the increase or decrease in revenue and expense per kw.-hr. over a three-year period. Substantiating data for ready reference are shown to the right of the main chart. Similar charts for other unit cost measurements can be used where desired. This type of data can be plotted to advantage on a ratio chart.

Chart F—The Gantt Budget Chart

This is one of the most practical forms of budget analysis for monthly use. On it are listed all the important individual budget estimates with the estimates recorded monthly and accumulative. The estimates are shown numerically and represent the total value for each month. The monthly estimate is in the upper left corner and the accumulative estimate in the upper right corner. The actual amount for items budgeted are then plotted in relation to the estimates. The light lines represent monthly totals and the heavy lines represent accumulative totals. The table gives the substantiating data.

This chart can be amplified to show comparative data other than estimates.

Summary

The ten charts have been prepared with but one aim in view, to organize operating and financial data in graphic and tabular form for monthly use by utility managers. The combination of tabular and graphic presentation giving quick perceptive characteristics, purposely have been incorporated in the charts because of the imminent need for conciseness. The comparative features also have been emphasized in each chart.

No attempt is made to cover the entire field of statistical presentation. There is however, suggestion enough in the forms used to call for amplification in much more detail than is given in this report. This, the committee hopes, will follow from the use of graphical methods of presentation. Many data, suitable for quarterly and yearly presentation, have been omitted because the essential aim herein has been to specialize upon monthly data.

Two methods of presenting statistical information to an executive are in vogue. In one case the statistician sends to each executive, monthly, a complete set of the charts for insertion in a loose-leaf notebook. In the other case the statistician keeps the chart records in a bound notebook and each month delivers them to the executive as soon as the charts are brought up to date. Either of the two methods is practical.

The committee sincerely hopes that the graphic method will be found useful, both as to form and content. It represents only the beginning in factual presentation.

PUBLIC UTILITY
OPERATING EXPENSE RATIOS

Month	Total Expense	Subdivision of Expense and Ratios						
		Production Expense	Transmission Expense	Distribution Expense	Utilization Expense	Commercial Expense	New Business Expense	General Expense
1928								
January	$ 117 960	$ 43 616	$ 5209	$ 20 958	$ 5795	$ 12 932	$ 11 992	$ 17 979
		37%	4.4%	17.8%	5.1%	11.0%	10.2%	14.8%
February	113 087	39 980	5 203	19 112	5 641	13 910	11 496	18 546
		35.0	4.6	16.9	4.9	12.3	9.9	16.4
March	116 916	40 798	5 471	19 365	5 616	13 866	11 607	18 963
		35.5	4.6	16.8	4.8	11.8	10.1	16.5
April	113 178	40 044	4 936	18 172	5 496	13 679	11 646	18 284
		35.7	4.4	16.2	4.9	12.1	10.4	16.3
May	112 482	40 606	4 837	18 936	5 449	13 610	11 923	19 122
		36.1	4.3	16.7	4.8	12.1	10.6	17.0
June	111 124	39 560	5 118	17 924	5 667	13 448	11 446	18 667
		35.6	4.6	15.6	5.1	12.3	10.3	16.6
July	111 386	39 910	5 458	17 579	5 769	13 923	11 581	17 936
		35.3	4.9	15.8	5.0	12.5	10.4	16.1
August	113 142	39 963	5 607	16 933	5 883	14 178	12 223	18 056
		35.1	5.0	15.1	5.1	12.0	10.9	16.1
September	110 379	38 62	5 701	16 226	5 188	14 680	12 365	17 661
		34.9	5.2	14.7	4.7	13.3	11.2	16.0
October	114 900	39 216	6 954	16 906	5 526	14 934	12 500	17 786
		34.4	6.1	14.9	4.9	13.1	11.0	15.6
November	118 000	39 706	6 835	16 675	5 966	15 298	12 906	18 400
		34.7	5.7	14.5	5.1	13.3	10.7	16.0
December	113 000	40 580	5 989	16 159	5 876	15 266	12 956	16 588
		36.0	5.3	14.3	5.2	13.6	11.2	14.5
Total	1 357 249	481 266	66 770	211 260	67 531	169 918	143 700	217 080
Annual Ave	113 104	40 101	5 564	17 605	5 628	14 160	11 975	18 085
1929								
January	119 000	45 339	8 581	17 098	6 907	16 303	12 952	11 875
		38.1	7.9	14.7	5.8	13.7	10.8	12.5
February	123 000	48 339	8 706	17 835	6 973	16 738	13 96	14 760
		39.3	6.8	14.5	5.1	13.6	10.7	12.0
March	116 000	42 360	8 916	16 736	5 606	15 992	11 258	17 900
		36.5	8.1	14.6	4.9	13.7	10.8	15.0
April								
May								
June								
July								
August								
September								
October								
November								
December								
Total								
Annual Av								

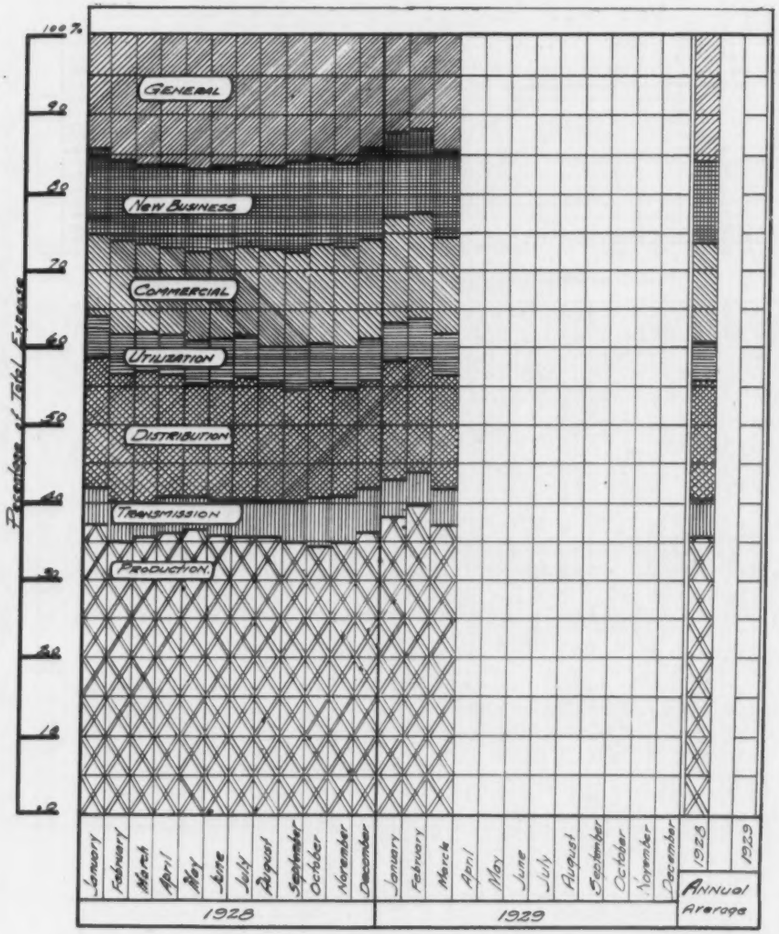


Fig. 4. Chart C-2. Analysis of operating expense ratios. Figures represent thousands of dollars.

Month 1928	Stores Purchased	Stores Issued	Stores Balance	Stores Bal. 1927	Inc. in Bal. over prev. year.
January	190,000	202,000	1400.000	1,700,000	-300000
12 Mo.	2,042,000	2,147,000	Av. 1,546,000	Av. 1,621,000	Av.-75000
February	190,000	205000	1375000	1679.000	-304000
12 Mo.	2,040,000	2,143,000	Av. 1520000	Av. 1,624,000	Av.-104000
March	180,000	201000	1364000	1,657,000	-293000
12 Mo.	2,041,000	2,140000	Av. 1504000	Av. 1,626.000	Av.-121000
April	172,000	199000	1337000	1,635,000	-298000
12 Mo.	2,038,000	2,138,000	Av. 1479000	Av. 1,625,000	Av.-146000
May	160,000	190000	1307000	1,616,000	-309000
12 Mo.	2,036,000	2,136,000	Av. 1454000	Av. 1,624,000	Av.-170000
June	157,000	185000	1280000	1596,000	-316000
12 Mo.	2,035,000	2,130,000	Av. 1427000	Av. 1,622,000	Av.-195000
July	159,000	182,000	1247000	1,566,000	-319000
12 Mo.	2,035000	2,129000	Av. 1400000	Av. 1,618,000	Av.-218000
August	158,000	180,000	1225000	1,535,000	-310000
12 Mo.	2,036,000	2,128,000	Av. 1374000	Av. 1,612,000	Av.-238000
September	160000	185000	1275000	1,608,000	-333000
12 Mo.	2,038,000	2,128000	Av. 1352000	Av. 1,603000	Av.-251000
October	160,000	190,000	1195,000	1,479000	-284000
12 Mo.	2,040000	2,129000	Av. 1327000	Av. 1,593,000	Av.-266000
November	170,000	195000	1170000	1453.000	-283000
12 Mo.	2,037,000	2,130,000	Av. 1305000	Av. 1,584,000	Av.-279000
December	175,000	200,000	1145000	1,424,000	-279000
12 Mo.	2,031,000	2,134,000	Av. 1281000	Av. 1,570,000	Av.-289000
1929					
January.	180,000	207000	1118000	1,400,000	-282000
12 Mo.	2,021,000	2,139000	Av. 1266000	Av. 1,546,000	Av.-280000
February	183,000	2,11000	1090000	1,375,000	-285000
12 Mo.	2,014,000	2,145000	Av. 1243000	Av. 1,520,000	Av.-277000
March				1,364,000	
				Av. 1,504,000	
April				1337000	
				Av. 1,479,000	
May				1,307,000	
				Av. 1,454,000	
June				1280,000	
				Av. 1427,000	
July				1247,000	
				Av. 1,400,000	
August				1225,000	
				Av. 1,374,000	
September				1275000	
				Av. 1,352,000	
October				1195,000	
				Av. 1,327,000	
November				1,170,000	
				Av. 1,305,000	
December				1,145,000	
				Av. 1,281,000	

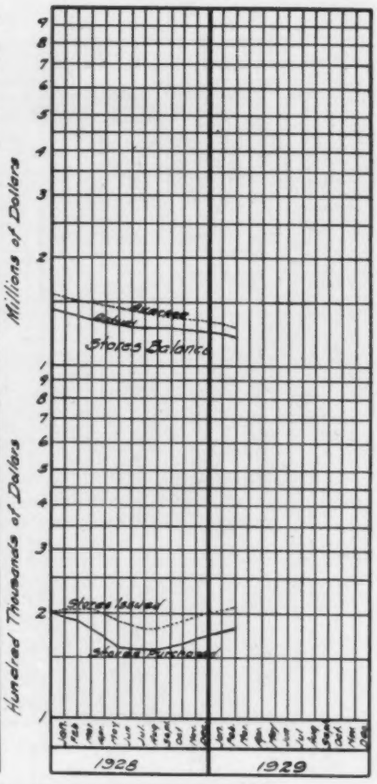


Fig. 5. Chart C-3. Stores movements. Analysis of expenses.

KWH GENERATED & PURCHASED
(In thousands)

Month	Present Year Estimate	Present Year Actual	Previous Year Actual	Increase over Prev. Year Actual	Increase over Prev. Year Percent
January	77200	82,190	72650	9,540	13.1 %
February	78400	80,598	68710	11,888	17.3 %
2 Mo.	155600	162,788	141360	21,428	15.1 %
March	79300	81,623	72660	8,963	12.4 %
3 Mo.	235900	244,211	213820	30,391	14.2 %
April	76900		68630		
4 Mo.	302800		282,350		
May	78400		71,300		
5 Mo.	381200		353650		
June	77700		70,100		
6 Mo.	444900		423750		
July	78900		71,630		
7 Mo.	543800		494,180		
August	79000		75,100		
8 Mo.	622800		570,280		
September	81100		72,820		
9 Mo.	703900		643,100		
October	86900		79,264		
10 Mo.	789800		722,364		
November	84000		77,536		
11 Mo.	873800		799,900		
December	88,200		79110		
12 Mo.	962300		879,000		

Month	12 Months Ending This Year	12 Months Ending Previous Year	Increase over previous year	Load Factor This Year	Load Factor Previous Year
January	888,540	802,990	82,550	68.0 %	68.7 %
February	900,428	810,890	89,538	73.0 %	73.2 %
March	949,391	816,180	93,211	71.3 %	74.0 %
April		820,550			70.1 %
May		826,030			70.9 %
June		831,380			68.2 %
July		838,260			71.5 %
August		846,520			69.0 %
September		853,290			68.0 %
October		863,230			64.5 %
November		872,000			64.7 %
December		879,000			66.0 %

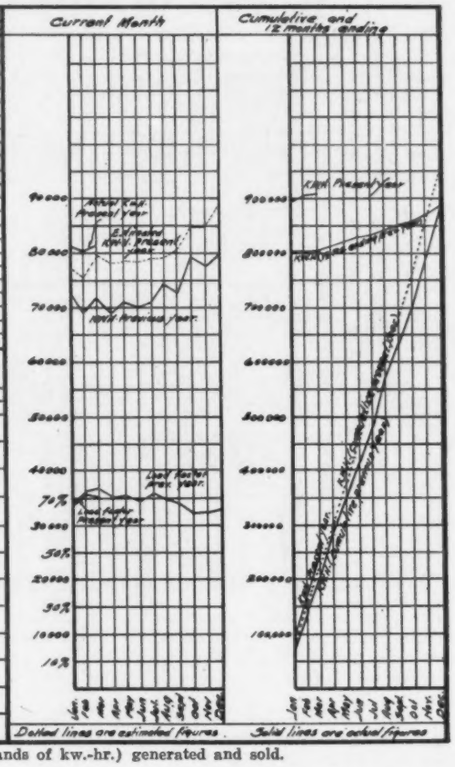
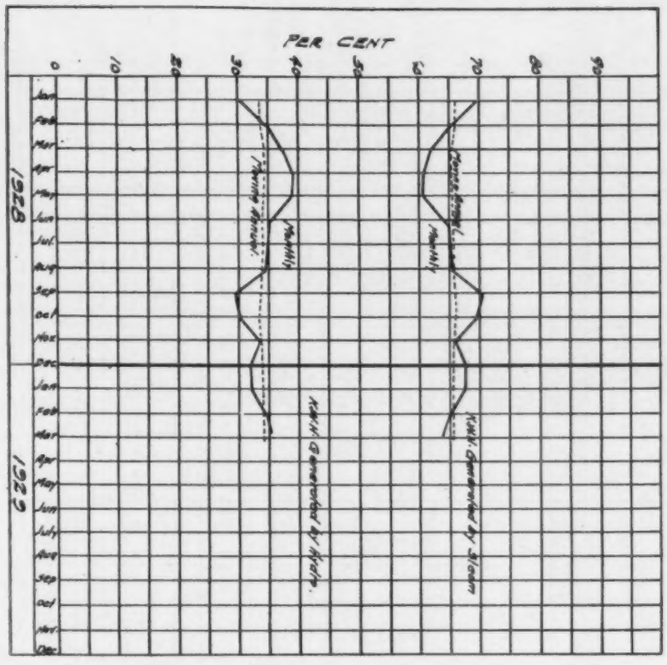


Fig. 6. Chart D-1. Analysis of power (expressed in thousands of kw.-hr.) generated and sold.



Hydro		Steam	
Monthly	12 Months Ending	Monthly	12 Months Ending
30.4	33.6	69.6	66.4
34.8	33.8	65.2	66.2
37.8	34.2	62.2	65.8
39.0	34.3	61.0	65.7
38.7	34.1	61.3	65.9
35.2	33.9	64.8	66.1
34.8	34.0	65.2	66.0
34.4	34.0	65.6	66.0
29.3	33.8	70.7	66.2
30.3	33.6	69.7	66.4
33.6	33.9	66.4	66.1
32.1	33.9	67.9	66.1
32.2	34.1	67.8	65.9
34.4	34.1	65.6	65.9
36.0	34.0	64.0	66.0

Fig. 7. Chart D-2. Ratio of hydro-electric and steam-electric energy generated to system total.

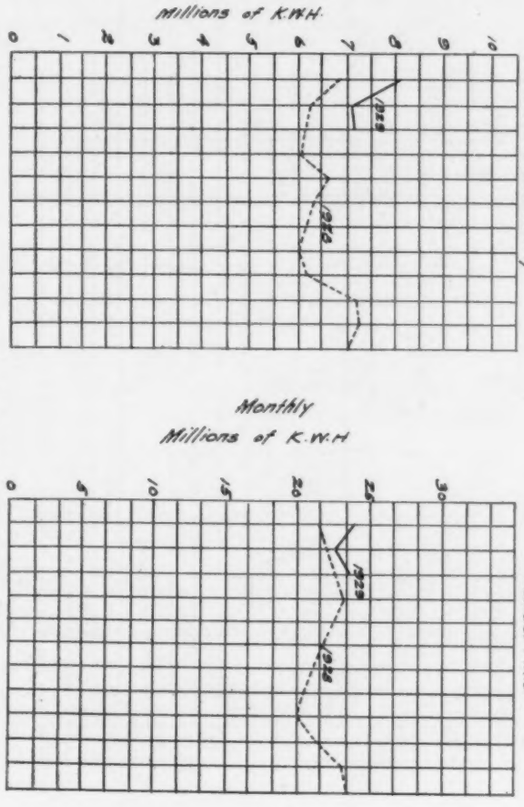
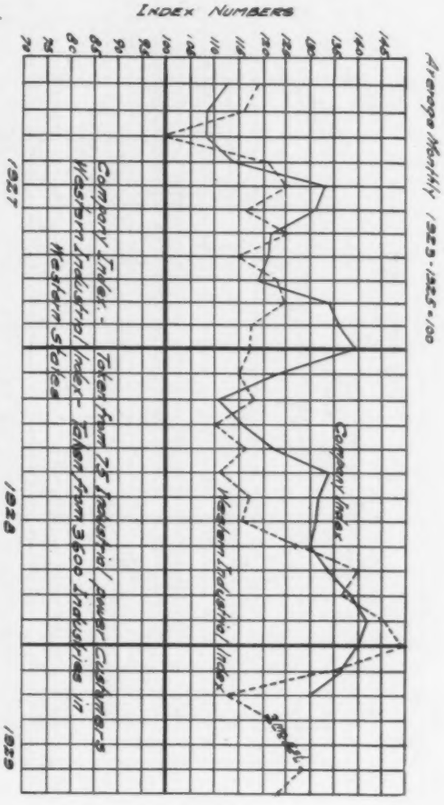


Fig. 8. Chart D-3. Industrial consumption with industrial index.


INDEX NUMBERS
Average Monthly 1923-1925=100
1927
1928
1929
Comparison of the amount of energy sold to the largest industrial consumers during 1929 with that sold in 1928
Company Index
Western Industrial Index
Ticket from 75 Industrial Power Customers
Western Industrial Index
Ticket from 3600 Industries in Western States
Company Index
Western Industrial Index

Monthly Expense per Kwh.	Annual Expense per Kwh.	Monthly Revenue per Kwh.	Annual Revenue per K.W.H.
0.89	0.91	1.69	1.63
0.88	0.90	1.70	1.63
0.85	0.90	1.64	1.62
0.86	0.90	1.65	1.63
0.88	0.89	1.64	1.62
0.88	0.89	1.64	1.64
0.91	0.89	1.65	1.64
0.90	0.89	1.60	1.64
0.92	0.89	1.66	1.65
0.92	0.90	1.66	1.66
0.89	0.90	1.71	1.66
0.94	0.89	1.77	1.67
1.00	0.90	1.78	1.68
0.92	0.91	1.71	1.68
0.90	0.91	1.67	1.68
0.88	0.91	1.64	1.68
0.86	0.91	1.60	1.68
0.88	0.91	1.60	1.67
0.91	0.91	1.62	1.67
0.90	0.91	1.53	1.67
0.92	0.92	1.62	1.66
0.96	0.92	1.58	1.65
0.96	0.92	1.64	1.64
0.91	0.92	1.70	1.64
0.94	0.93	1.65	1.63
0.93	0.93	1.67	1.63
0.92	0.94	1.68	1.64

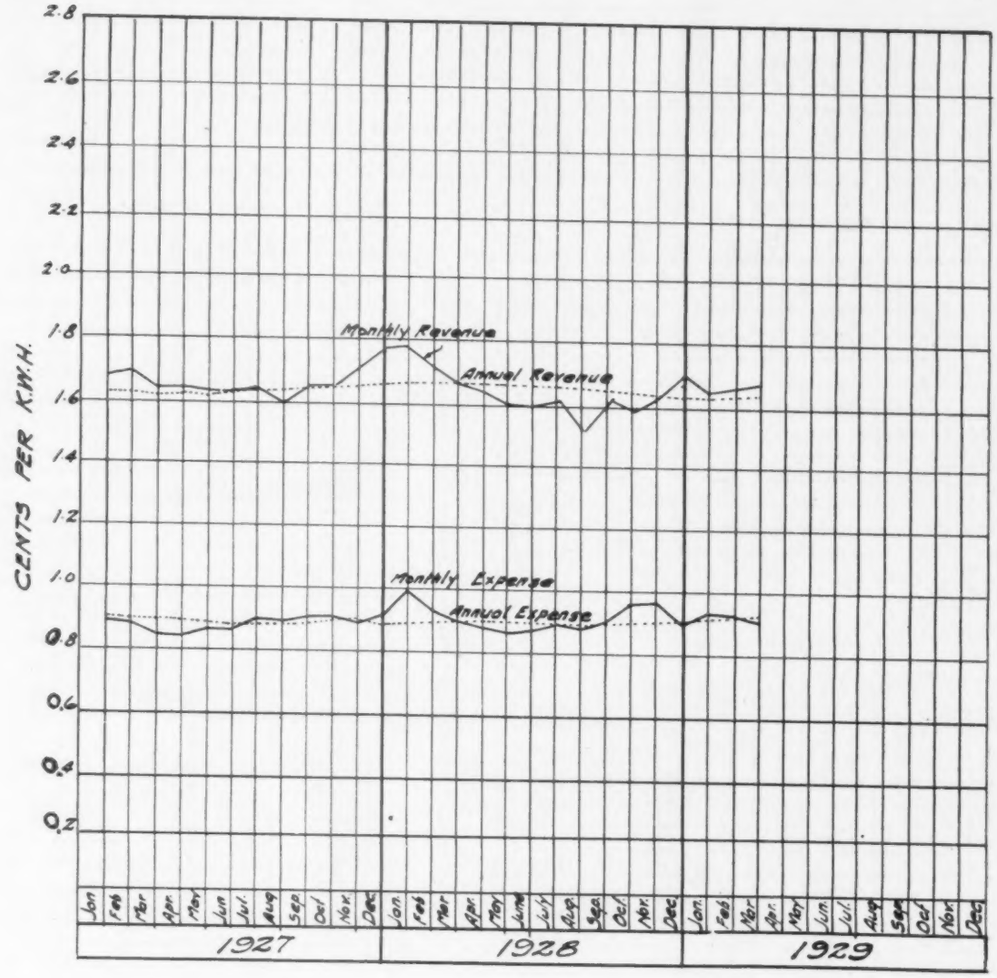


Fig. 9. Chart E. Analysis of unit costs. Revenue and expense per kw.-hr. sold.

1929 - Gantt Budget Chart

Chart F

Subject		Jan.		Feb.		Mar		Apr.		May		June		July		Aug		Sept		Oct		Nov.		Dec.	
		Monthly	Acc.	Monthly	Acc.	Monthly	Acc.	Monthly	Acc.	Monthly	Acc.	Monthly	Acc.	Monthly	rice	Monthly	Acc.	Monthly	Acc	Monthly	Acc.	Monthly	Acc.	Monthly	Acc
Construction (in thousands)	Est	246		283	529	327	856	274	1130	325	1455	375	1830	315	2145	329	2474	248	2722	198	2920	250	3170	250	3420
	Actual	335		257	592	305	897																		
Purchases (in thousands)	Est	190		190	380	180	560	172	732	160	892	157	1049	159	1208	158	1366	160	1526	160	1686	170	1856	175	2031
	Actual	180		183	363	172	535																		
Stores on hand (in thousands)	Est	1400		1375		1364		1337		1307		1280		1247		1225		1226		1195		1170		1145	
	Actual	1118		1090		1023																			
New Bus Conn (in thousands)	Est	132		100	232	97	329	95	424	110	534	60	594	68	662	74	736	97	833	80	913	69	982	87	1069
	Actual	38		6	44	43	87																		
New Cons Added (actual number)	Est	875		850	1725	940	2665	860	3526	965	4490	860	5350	875	6225	995	7220	1000	8220	1020	9240	1030	10270	930	11200
	Actual	532		484	1016	723	1739																		
KWH Sold (in hundred thousands)	Est	1053		1057	2110	1069	3179	1104	4283	1103	5386	1097	6483	1065	7548	1104	8652	1087	9739	1114	10853	1182	12035	1190	13225
	Actual	1162		998	2160	1073	3233																		
Prod. Exp. (in thousands)	Est	289		293	582	225	747	215	962	238	1200	229	1429	252	1681	303	1984	371	2355	551	2906	437	3343	446	3789
	Actual	304		297	601	324	924																		
Dist Exp. (in thousands)	Est	58		51	106	52	158	47	205	49	254	46	300	38	338	39	377	39	416	48	464	41	505	48	553
	Actual	50		48	98	51	149																		
Comm Exp. (in thousands)	Est	118		117	235	111	346	116	462	114	576	122	698	115	813	118	931	127	1058	134	1192	131	1323	131	1454
	Actual	127		126	253	124	377																		
New Bus Exp (in thousands)	Est	58		60	118	59	177	61	237	65	303	69	372	56	428	69	497	62	559	63	622	64	686	70	756
	Actual	56		57	113	58	171																		
General Exp (in thousands)	Est	286		278	564	277	841	293	1134	241	1375	263	1638	278	1916	261	2177	252	2429	268	2697	308	3005	237	3242
	Actual	250		263	513	271	784																		
Maint Exp. (in thousands)	Est	53		44	97	46	143	50	193	43	236	42	278	43	321	43	364	42	406	39	445	40	485	39	524
	Actual	40		21	81	43	124																		
Total Exp. (in thousands)	Est	859		783	1642	770	2412	782	3194	750	3944	771	4715	782	5497	833	6330	893	7223	1103	8326	1021	9347	971	10318
	Actual	827		832	1659	871	2530																		
Gross Rev. (in thousands)	Est	1449		1385	2834	1362	4196	1367	5563	1324	6887	1318	8205	1298	9503	1291	10794	1328	12122	1518	13640	1480	15120	1547	16667
	Actual	1457		1325	2782	1321	4103																		
Net Earnings (in thousands)	Est	590		602	1192	592	1784	585	2369	574	2943	547	3490	516	4006	458	4464	435	4899	415	5314	459	5773	576	6349
	Actual	630		493	1123	450	1573																		

Fig. 10. 1929 Gantt budget chart.

Fig. 11. Continuation of 1929 Gantt budget chart.

Commercial Section Reports[1]

Pomotional Rates*

CAN WE not find a better name for this type of rate? We are asking this question because when one considers the various meanings implied by the word "promotional," some of which are not at all pleasing to the ear of the public, a change is to be desired. The title is of course permissible when we are discussing the question among ourselves, but do not let the public get the idea that promotional rates have any connection with promotion as they understand that word.

A number of years ago Prof. W. D. Marks, after studying the electric rates and per capita consumption of electric current in several New England cities, found that these two quantities were connected by a very simple mathematical law. Today we are going to discuss a certain phase of this question, that is, a rate that would allow this law to operate freely and at the same time protect the operating company.

In order that we may confine our discussion within the limits provided, let us first define the term "Promotional Rates." A promotional rate, as we understand the term, is a rate that will permit the largest use at a moderate cost, but only (please note this) after the initial cost of providing the customer with the necessary investment has been defrayed by either a fixed charge independent of number of kw.-hr. used or a higher price for the first few kw.-hr. Further we will confine our discussion to low load factor lighting business—residential and small commercial customers. If we included power and large commercial customers, we would be covering a territory which has been investigated and discussed many times before, and would render this paper of greater length than is desired.

From the most reliable information obtainable, it would seem that there are over 19,000,000 wired houses in the United States, but, when we consider that a high average rate of use in these houses is 1¼ kw.-hr. per house per day, we must realize that much is yet to be done to really develop this business and improve the situation. Unfortunately in the past, and to some extent at this time, central station executives have been prone to say, "The residential customer pays us only one or two dollars per month—why bother with this class of business? Rather let us devote our time and attention to the big fellow." This attitude is undoubtedly attributable to what the residential customer used to do, not to what can be expected today if proper attention is devoted to this class of business. Many fail to recognize the importance of putting each kilowatt attached to our system to work as many hours a day as possible. With the same investment, 1 kw. used 24 hours a day is of far greater importance than 24 kw. used one hour. For this reason our rates for that additional electric service which pertains to facilities and appliances in addition to the ordinary lighting use should be made as low as the cost of such additional service will permit. If this is done, the price will be such that our customers will willingly avail themselves of the economical opportunity to use more electric service.

Consider fixed costs and follow-on costs for each class of business and, where possible, for each customer. In the follow-on cost for the longer use we find that the principal items are certain operating expenses. What do they amount to? Whatever the rate or charge may be for the first block to the residential or small commercial customer, that portion representing the operating cost is so small that we can make a rate for the additional hours used so low that it will necessarily increase the hours used. It is a fact that of the total cost of serving a residential customer the operating costs are small, certainly not over 20 per cent. This would indicate that your costs would be little affected if the average residential use was increased. From this it also follows that for the low-use customer to pay his keep the kw.-hr. rate in the first step of the rate schedule must be relatively high.

A recent investigation of the usual form of promotional rates by the business school of a large Eastern university disclosed the following: first, a reduction in the price of the second step has the greatest effect—the extent of the price differential between the top step and the second step produces the greatest increase in consumption and revenue; second, a decrease in the sum produced by the first step is of next importance; and third, a change in the price of the first step has the least influence in increasing consumption and revenue.

Would it not be well if we investigate and find out to what extent our costs would be affected if our residential customers increase their use from an average of 40 kw.-hr. per month to 60, 80, 100, or over 200 kw.-hr. per month. We should also include in these figures the effect that such increased use would have on our station load factor and our profits. Undoubtedly such figures in some cases would be startling.

Doubtless future generations will never cease to wonder how people of this time were able to get along with so small an annual use of electrical energy.

Finally, a rate so designed as to allow each customer to utilize to a maximum the facilities required to serve him is the rate that we should all strive for, and this is another definition for a "promotional rate."

Farm Electrification*

Survey of Number of Electrified Farms In the Northwest

Preliminary Survey—A preliminary survey was made of the approximte number of farms connected to central stations of the Northwest, with the following findings:

Washington	34,443 farms
Oregon	11,428 farms
Idaho	7,215 farms
Utah	10,114 farms
Montana	663 farms

Survey of Actual Count of Farms—A questionnaire has been sent out to the different companies in the Northwest, calling for the actual number of farms connected, annual kw.-hr. consumed by farms, and the revenue from farm service, also the number of miles of rural lines.

Returns are not complete on this survey, and the results will have to be omitted in this report. However, the report on this survey will be prepared as soon as possible.

Survey of Rural Electrification Organizations Within the Companies

This committee made a complete survey of the rural electrification organizations within the companies of the Northwest, which was reported in detail to the national committee, and since the results will be included in the national committee report they are omitted here.

Farms Using in Excess of 3,000 Kw.-hr. Per Year

A report was made on several farms of each state using in excess of 3,000 kw.-hr. of electricity annually. Since the details of this investigation will be included in the national committee report, they are omitted here.

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[1]Executive Committee—L. A. Lewis, The Washington Water Power Company, chairman. T. M. Gibbes, V. H. Moon, R. C. Saunders, J. S. Scott, W. A. Schoel, E. E. Scofield, Fred Zaugg.

* Report of promotional rates committee—**Thos. M. Gibbes,** Puget Sound Power & Light Company, chairman. **Grays Harbor Railway & Light Company:** H. J. Flagg. **Northwestern Electric Company:** D. F. McCurrach. **Portland Electric Power Company:** F. H. Murphy.

* Report of farm electrification committee—**J. C. Scott,** Puget Sound Power & Light Company, chairman. **The California Oregon Power Company:** J. C. Thompson. **Eastern Oregon Light & Power Company:** J. P. Lottridge. **Grays Harbor Railway & Light Company:** H. G. Kelsey. **Idaho Power Company:** J. C. Baldridge. **Mountain States Power Company:** H. C. Wells. **Northwestern Electric Company:** F. H. Robinson. **Pacific Power & Light Company:** George Hibbert. **Portland Electric Power Company:** W. M. Hamilton. **Utah Power & Light Company:** E. R. Owen. **The Washington Water Power Company:** J. F. Farquhar.

Fig. 11. Continuation of 1929 Gantt budget chart.

Schools

Two schools have been held for rural electrification service men—one conducted by the Oregon State College, Corvallis, Ore., Feb. 18-23, 1929, and one conducted by the Washington State College, Pullman, Wash., March 4-6, 1929.

These schools were well attended and the benefits derived are of great value to the companies as well as to everyone concerned in the farm electrification movement.

State Committees on the Relation of Electricity to Agriculture

Both the Oregon and Washington committees on the relation of electricity to agriculture are well organized and functionning to the very best advantage of the farm electrification program.

Spokane Meeting

There was one meeting of the farm electrification committee held this year, which was in conjunction with the mid-year conference of the Commercial Section of the Northwest Electric Light and Power Association, at Spokane, Feb. 28, and March 1-2, 1929.

Friday afternoon, March 1, and Saturday morning, March 2, were given over entirely to the farm electrification committee.

Friday afternoon was devoted to the discussion of selling equipment to the farmer. Papers were read as follows:

"How to Sell Equipment to the Farmer," George Hibbert, Pacific Power & Light Company.

"Analysis to Determine Sales Possibilities to Farmers," H. C. Wells, Mountain States Power Company.

"Equipment Proving Most Popular on the Farm," E. R. Owen, Utah Power & Light Company.

"Suggestions from the Manufacturer on Selling to the Farmer," L. R. Elder, General Electric Company, and C. V. Aspinwall, Westinghouse Electric Company.

"Co-operation of Dealers and How to Secure It," W. M. Hamilton, Portland Electric Power Company.

"How to Find Prospects," F. H. Robinson, Northwestern Electric Company.

"Should Power Companies Sell Equipment Direct to Farmer or Leave It Entirely to Dealers?" J. F. Farquhar, The Washington Water Power Company.

"Equipment Demonstrations, Motion Pictures, Etc.," F. H. Robinson, Northwestern Electric Company.

"How to Get the Farmer to Buy Quality Merchandise Rather Than on Price Only," H. G. Kelsey, Grays Harbor Railway & Light Company.

"Methods and Program of Work of Farm Electrification Specialists Who Do Not Sell to the Farmer," J. C. Baldridge, Idaho Power Company.

There was a discussion from the floor on the following subjects:

1. Work on the state Committees on the Relation of Electricity to Agriculture.
2. State electrical inspection.
3. The farmer who does his own work.
4. Utility motor—size best adapted to farm work.
5. How much selling should a farm service man do?
6. Is a one-meter rate advisable?

Not all the important points brought out in this session can be incorporated in this report, but a few of the high lights are as follows:

How to Find Prospects—Employee contact is very vital. Each employee, whether in the office or on the line, can contribute much by talking with his friends or any one that he may come in contact with, either during his daily task or when off duty, and turning in a report of any likely prospect. This does not mean much time on the employee's part as a general rule; in fact, it should not interfere with regular duties, but a few minutes conversation here or there may divulge a secret hankering on the part of a prospect for some article that could be easily sold if followed up at once. There are different ways of compensating an employee so as to make him feel as though his efforts were appreciated by the company. A small commission for a sale that has been closed by the regular sales force on a prospect turned in, may be given.

Secure names of those calling at your store who seem interested and make it a point to call on them. Anyone calling at the office to pay a bill or for any other purpose is, perhaps, a prospect for something electrical if it were but brought to his attention in a pleasing manner. If attention is called to some article, especially a newly acquired one, the customer will in many cases appreciate the service and perhaps purchase at the time or let it be known that he is interested enough to have someone call on him later.

Selling to the Farmer—Create in the prospect's mind confidence in your company and in yourself.

Don't knock the other fellow or his goods, but be sold on your own and speak a good word for the other fellow. He has to live and in pursuing his business he is building load on our lines.

Most farmers are slow buyers and won't listen to high pressure more than once. We must depend on repeats.

Put yourself in the customer's position and respect his opinion even though it may not be the same as your own.

Study your customer's needs and you may find something that he had not known, or thought of. He will appreciate this.

After selling to a customer, drop around later and see if he is perfectly satisfied and if he needs any advice or assistance, and ten to one he will not forget to call for you when he wants anything that you can furnish him.

Equipment Demonstration—The demonstrating of electrical equipment in some form or other is carried on by most power companies throughout the country. Many companies select one or more farms that are operated by a progressive farmer and equip or supervise the equipping of the farm with electrically operated farm machinery to be used under ordinary practical conditions.

A general farm containing acreage enough to allow for the raising of feed for and the handling of from twenty to forty head of milking cows, some hogs, poultry, etc., makes an ideal demonstration farm. This type of farm can be equipped with electric hay hoist, silo filler, feed cutter, feed grinder, milking machine, refrigeration, water-heating and sterilizing equipment. Along with this will come proper lighting of the poultry house and heating drinking water, automatic water pumping, incubators and brooders.

The electrically equipped farm dwelling should not be overlooked, as it affords an opportunity to demonstrate what can be done when proper wiring is installed. The electric range and house appliances may be shown in operation to great advantage.

Farm Meeting—Talks made before grange and farm meetings are very effective in introducing and popularizing the use of electricity on the farm. The company should stand ready to furnish an entire program for such meetings, perhaps with the aid of motion pictures, which are available for this purpose.

The agriculture extension departments of the state colleges have a large list of films on farm management, dairying, soils, etc., that may be had for the asking. All that is asked is that the user pay the express charges and assume responsibility for any loss or damage to the films while in the possession of the user. The U. S. Repartment of Agriculture and the General Electric Company both have many films that are of interest to the farmer. These are loaned on the same basis as those of the agricultural colleges. These films are educational and cover subjects such as the use of electricity, the manufacturing of motors and lamps and the care of farm machinery.

Exhibits at Fairs—Equipment for fairs may best be maintained as permanent exhibiting equipment that may be used yearly or oftener and can be added to from time to time. Exhibiting at state fairs is of greater value on account of the larger attendance than at county fairs.

Quality Merchandise—The average farmer is inclined to abuse his farm equipment by neglect. It is a common sight to see such equipment kept in open storage and subject to the action of the elements. Under these conditions we can expect that the electrical equipment will fare no better. For this reason it is important that we sell merchandise which will stand up and operate under difficult conditions.

Even the best of equipment will wear and deteriorate under continual operation, but quality merchandise will continue to give results with less service requirements. However, when replacement or repair is necessary the reliable retailer is in the best position to give this service promptly and economically. If the equipment to be repaired was purchased on price alone it is extremely doubtful whether the seller will have the repair

parts or the service department to install them. If it is necessary to send away for parts the delay is inconvenient and costly, and there is always the chance that the manufacturer of low priced equipment has changed models and discontinued the parts or has gone out of business entirely. It is to the farmer's advantage and protection then to buy quality merchandise.

Different Viewpoints on the General Problem

On Saturday morning, March 2, the meeting was given over to papers concerning the developing of an appreciation of the value of electric service on the farm. Addresses as follows were given:

"Within the Power Company Organization"
A. C. McMicken, general sales manager, Portland Electric Power Company, Portland.

"From the Standpoint of the Agricultural Editor,"
Fred W. Clemens, assistant to the editor, Washington, Oregon and Idaho Farmer, Spokane, Washington.

"Training for a Larger Responsibility,"
Dr. E. O. Holland, president, Washington State College, Pullman.

While all these talks were most interesting and instructive, the one by Mr. Clemens appears to the committee to epitomize a viewpoint from outside our industry that is basic and fundamental in the general problem of farm electrification. For this reason Mr. Clemens' talk is reproduced here practically in full, in the hope that more and more utility representatives charged with the promotion of farm electrification may be brought to a more complete understanding of the farmer's side of the problem so essential to the success of the rural electrification program.

Viewpoint of the Agricultural Editor—Mr. Clemens' remarks follow:

There are several viewpoints on this matter of developing an appreciation of electricity for farm purposes —the viewpoints of the man engaged in promoting the electrical business, of the college, of the farmer, of the banker, of the editor and so on. It is true that these viewpoints differ in some particulars. There are, however, fundamental and indisputable facts pertaining to the use of electricity on the farm, and your viewpoints and mine must square with those facts. In whatever degree they do not so square, the development of the use of electricity for rural purposes will be undesirably retarded.

I well remember an incident at a farmers' luncheon some two years ago that seems worth relating. One farmer brought up for discussion the question of the rural schools. "How," he inquired, "can we so manage our rural schools as to give our boys and girls the quality of education we want them to have?" The problem was discussed for some little time, but was not solved until another farmer settled the matter after this fashion: "I'll tell you how to solve the rural school problem. Pass the McNary-Haugen bill."

What he meant was, make the people in your rural community prosperous and they will take care of their own school situation.

I am not discussing the merits of the McNary-Haugen bill, but I am joining with that gentleman in laying down as a fundamental principle of rural development along almost any line the absolute necessity of dollars and cents prosperity. The application of electricity to the farm is no exception.

I take the liberty of quoting from an article I wrote after attending a meeting of the Washington C.R.E.A.

"If farms are to be electrified, electricity must pay in dollars and cents. It must grind feed, pump water, warm water, wash clothing, thresh grain, fill silos, cut hay, elevate grain, milk the cows, churn the butter, heat the hotbed, sterilize the dairy utensils and otherwise increase the actual money-making efficiency of the farm. On the basis of comfort and convenience alone it will never win its way into rural life, as it has already done in city life, however low the rates may become and whether under private or public ownership of utilities."

I cannot tell you specialists how to make electricity profitable to the farm. That involves costs of producing power, costs of transmission, costs of equipment and appliances, work to be done on the farm, volume of business and a host of other things with which only those who have made specialized study can be familiar. But I can tell you that it must be made profitable or our efforts are in vain.

Let me impose upon your good nature by reading a few other lines of the same article from which I just quoted. I hesitate to do so because I am uncertain, as I was when I wrote it, as to the accuracy of the figures. Disregard the specific figures, therefore, and take only the idea:

"'Proper warming of the water in the poultry house will increase production 10 to 25 eggs per hen.'

"L. C. Beall, poultryman of western Washington, and a member of the state committee on the Relation of Electricity to Agriculture, made the remark in a casual sort of way at the recent meeting of the committee. The writer did a little hasty figuring to see what that statement really meant.

"Put it at a dozen eggs per hen. Say a poultryman has 1,000 hens. That means 1,000 dozens of eggs increased production. At an average of 25 cents per dozen (and that water-warming business comes at a time when eggs are highest), that would mean $250 increased revenue to that single 1,000-hen poultryman."

Daniel Webster never delivered a more eloquent oration in behalf of the Union than is a statement of that character in behalf of a water-warming device on the poultry farm. A column of generalized matter on the value of electricity will not stimulate poultrymen to adapt it to their uses as will specific instances of where Mr. Beall or Mr. Smith or Mr. Jones actually made it pay increased dollars.

Individual farmers to whom electricity has been made available have made various demonstrations of this kind. The experiment stations are working out ways and means of putting electricity into practical service on the farms. The Committee on the Relation of Electricity to Agriculture is making surveys that bring to light important facts. Professor Smith stated at the recent meeting of that committee that already 100 practical uses had been demonstrated, and that many of them were in use on the 35,000 farms already electrified in this state.

As time goes on more and more uses will be discovered and their practicability demonstrated, and more and more farms will be tapping the wires for power—if that fundamental premise of dollars and cents is adhered to.

There is also a reverse side to this matter. There are 100 things electricity will do successfully, from cutting the children's hair to cutting the corn for silage, and there are one hundred things that it will not do successfully at the present stage of development. There are conditions under which it will not do certain of its jobs and return to the farmer cost plus.

It is just as important that these limitations be taken into consideration as that the possibilities be seized upon and developed. It is almost, if not quite as vital that those working on these problems find out the conditions under which it will not be profitable to both power company and farmer as that they find out the conditions under which it will be profitable. Installation where it is impractical, regardless of the reason, is a tragedy that results in acute injury to those directly affected and retards permanent and greatly to be desired development.

This may appear to have little to do with the subject of developing an appreciation of the value of electric service on the farm, but it has much to do with it.

Farmers already appreciate in a general way the desirability of electricity far beyond what they consider to be their opportunity to acquire it. No oratory on the enjoyment of white light; no flowery word pictures in the columns of the press about setting wheels in motion by pressing a button are necessary, nor will they greatly increase the appreciation of the value of electricity.

In whatever way it may be brought about—by private concern, public ownership, the harnessing of the brook that traverses the farm, the installation of a plant in the basement—make electricity permanently and economically available to light the farm home, churn the butter, grind the feed, pump the water, milk the cows, fill the silo and do the other 95 jobs for which it has been proved adapted, and the farm will become electrified without high-powered persuasion. And when it is done, rural life will have been revolutionized.

I see few enterprises that embody so great possibility for the advancement in rural life of those things that we think go to make up civilization as the increased availability of electrical power to the farming communities. So great are those possibilities, and so prone

are we to wax enthusiastic over them, that I would almost sound a note of warning that the development may come faster than the life and industry of the rural precincts can absorb it.

Our job is to develop upon a sound basis, clinging steadfastly to fundamental principles; proving our way as we go step by step; remembering that one failure may do more injury than several successes can do good toward the general goal of better rural living.

For better or for worse, these are a few thoughts of one agricultural editor stimulated by the subject of developing an appreciation of the value of electric service on the farm, but perhaps having little bearing upon that subject.

LIGHTING BUREAU

THE lighting bureau this year is made up of four subcommittees studying respectively home lighting education, industrial and commercial lighting, electrical advertising, and street and highway lighting. This conforms with the national bureau and the activities of the respective committees have tied in very closely.

It has been the endeavor of each subcommittee to gather information of a reliable, practical and workable nature that will be of material benefit to the member companies or others that are interested. The reports cover in detail several highly successful activities for the development and promotion of lighting that were carried on during the past year by various companies in this division. This should be useful to the lighting departments of other companies.

Commercial and Industrial Lighting*

THE electric lighting industry is today facing two problems of primary importance in the field of commercial and industrial lighting—first, the need of a well organized and intensive sales program in industrial lighting, and second, the establishment of better contact with architects. The latter phase of the problem was recognized at a meeting of the Commercial-Industrial Lighting Committee, N.E.L.A. held in October, 1928, where plans for a national campaign were adopted. They outlined at that time a program for the current year, which stated briefly is as follows:

(a) To interest the builders of new commercial and industrial buildings in the necessity of adequate lighting and adequate wiring.

(b) To recommend that all power companies serving a population of 20,000 or more maintain an efficiently operated lighting service department.

(c) To carry on advertising in the six leading architectural magazines to stimulate the interest of architects in better lighting, and to encourage better co-operation on the part of architects and consulting engineers with the central station companies' lighting specialists.

As further evidence of the feeling throughout the industry toward the necessity of promoting better co-operation between the three groups, namely architects, electrical contractors and lighting specialists representing public utility companies, the following is quoted from the announcement of the conference of lighting specialists held at Nela Park, Cleveland in January, 1929:

The Lighting Sales Bureau, N.E.L.A., under whose auspices this conference is conducted, has long striven to effect a better understanding and a better contact with architects and electrical contractors. Because of the utter dependence of real progress on mutual co-operation with these groups and because, without exception, lighting specialists everywhere have named this a major problem, the conference this year has put many other important questions secondary to the development of a program which seeks a frank discussion of these mutual relationships and responsibilities.

Architects in the past have had plenty of contact with lighting salesmen, and may not through this contact have gained a clear picture of the character and purpose of the lighting specialist. On the other hand it is undoubtedly true that the lighting specialists have had few glimpses of the requirements of an architect's office and his method of operation.

This conference should contribute to a better mutual understanding and better relations between the two groups. The program is planned to mirror the point of view of both architect and lighting engineer.

Intensive Sales Program Needed

The need for an intensive sales program in industrial lighting stares the industry in the face today. No doubt largely as a result of the industrial lighting contest in 1925 the manufacturers of lighting equipment have come to realize the enormous potential market for their merchandise. Many lighting jobs were sold to large industrial plants. The owners of these factories were quick to discover the importance of adequate illumination. They saw their production increase, the waste of materials decrease, the accident hazard lessen, when their operators could see more clearly and, in general, an improved state of mind among the employees lead to better work. As a result the equipment manufacturer has found the plant owner a ready customer and has increased his advertising expenditure, most of which is directed toward the industrial manager and his engineers.

If this advertising is to have its intended effect local sales contacts must be established. The advertising itself is not intended to make the sales. It will, of course, stimulate interest, arouse desire and create a receptive attitude on the part of the prospective buyer toward the discussion of lighting as a factor in efficient plant operation. But in most cases the salesman and the prospect must meet fact to face if an order is to be obtained. The responsibility of establishing these contacts seems to rest with the central station if the load is to be established on the lines.

The manufacturers and jobbers of lighting accessories are always at the service of the power companies, offering sales and engineering assistance. Seldom, however, are they equipped with sales organizations large enough to conduct intensive sales campaigns directly with the consumer. The smaller industrial plants, many of which will be found in every community, are particularly neglected. The same condition exists in the commercial lighting field.

Study of Experience

With the program of the national committee in mind, our committee has made a study of the experiences of our member companies in this field. Six of the northwest companies maintain lighting service departments, all with considerable profit to themselves—namely: Northwestern Electric Company, Pacific Power and Light Company, Portland Electric Power Company, Idaho Power Company, The Washington Water Power Company, and Utah Power & Light Company. While the problems of sales promotion and of methods used differ somewhat in each locality, they all agree upon the need of a campaign based on a continuous program rather than on spasmodic activities of short duration employing temporary salesmen.

The Portland Electric Power Company has operated during 1928 as part of its lighting activities an industrial campaign in conjunction with one of the larger manufacturers of industrial lighting equipment. A series of broadsides and letters directed to managers, engineers and executives of industrial plants were mailed at regular intervals, emphasizing the value of adequate illumination in increasing the productivity of the plant. Lighting surveys were made and reports drawn up comparing their lighting with newly accepted standards of industrial illumination. Definite recommendations were contained as to changes needed in both lighting equipment and wiring. In many cases trial installations were set up in a part of a plant to create a contrast under actual working conditions. This proved to both operators and executives alike the common truth that a man working under ideal lighting conditions can almost automatically accomplish more than his fellow worker, perhaps as diligent or industrious, who is hampered by unfavorable conditions.

Another important feature of the campaign has been the use of photographs, taken before and after the improvement is made as a sales medium. These photo-

* Report of commercial and industrial lighting committee—**L. B. Gawan**, Utah Power & Light Company, chairman. **Benjamin Electric Company**: M. L. Fowler. **Idaho Power Company**: H. O. Stains. **Portland Electric Power Company**: L. D. Johnson. **Utah Power & Light Company**: Raymond Ackerman.

graphs cannot fail to arouse the interest of the next prospect interviewed, particularly if he is engaged in a business of the same nature.

As a result of this activity during twelve months 222 sales have been made adding to the lines of the company 307.19 kw. In order to gain this load the company has in some cases sold the lighting equipment and the wiring. In other cases the industrials have preferred to purchase the equipment outright, either installing the wiring themselves or employing their electrical contractors directly. Where necessary, credit conditions permitting, the company has carried the wiring and fixture account on a deferred payment plan. Materials sold during this campaign have amounted to $10,401, of which total the fixture sales were $7,099.27, wiring $2,479.98 and lamps $881.75. The above figures do not include items sold by other electrical firms in cases where the company furnished only the engineering service resulting in the sale.

A considerable portion of the time of one illuminating engineer and four lighting salesmen has been devoted to this campaign. The sales expenditure has been less than thirty cents for each one dollar estimated annual revenue gained. This is considered an exceptionally good showing in view of the fact that much time was consumed in educational work before the sales activities were well under way.

At Salt Lake City, the principal division of the Utah Power & Light Company, the Lighting Service Bureau of the Electrical League of Utah, was organized in February, 1923. This organization is still functioning, and while Salt Lake City's population is 130,000 the steady increase in the demand for its services, as well as the enlargement of the scope of its work, has made necessary an increase in personnel from one to seven persons in a six year period.

The expenses of operating this bureau are paid by the central station company. However, in order that the interests of all branches of the electric lighting industry may be served, an advisory committee is selected by the board of trustees of the league to direct in general the activities and policies of the bureau. This committee consists of five members: three representatives of Mazda lamp manufacturers, one electrical contractor and one central station man. The bureau serves as a clearing house for lighting information to which contractors, builders, architects, and the general public may submit their lighting problems. This bureau is now consulted in the majority of cases where any lighting or wiring problems are involved.

As an indication of the growth of this work, we are setting down below a brief tabulation which is self-explanatory:

Commercial and Industrial Lighting

Year	Increase in kw. Load added to lines	Estimated kw.-hr. per year.
1923	12.80	20,400
1924	149.40	239,000
1925	113.40	154,000
1926	137.00	277,000
1927	170.30	400,000
1928	429.21	610,000

The above table will readily show the value of such a department as a load builder. The tabulations include only interior lighting for commercial and industrial buildings, such as factories, stores, offices, etc. It does not include such items as are covered by the report of the Electrical Advertising Committee, including sign lighting, exterior lighting, billboard lighting, floodlighting, and show window lighting. The bureau has concentrated its major activities toward the electrical advertising field as Salt Lake City does not contain many large industrial plants. Also because there is less sales resistance to lighting for advertising purposes, it seemed the natural place to begin work of this nature. The sales expenditure has averaged less than 20 cents for each dollar of revenue gained for a one-year period.

Lighting Department Organization

Reports from all of the companies in the Northwest who conduct activities in this field of lighting tend to substantiate the statement that the activities in general are profitable. It seems, therefore, consistent that this committee recommend that all our member companies carefully investigate the possibilities of establishing lighting service departments as divisions of the commercial or sales organizations. We agree with the national committee that at least one trained lighting specialist should be employed by any company serving a population of more than 20,000.

The size of the department should, of course, depend directly upon the population of the community and the number of commercial and industrial accounts on the company's lines. Even in communities where these departments have been established for some time the majority of the stores, factories and offices are still in need of better lighting. It should be the duties of this department to establish contacts with architects, builders, electrical contractors, industrial plant owners and to offer the services of the company in analyzing their lighting problems. Any information desired regarding the planning of wiring systems for new buildings should also be furnished.

Valuable Points of Contact

It has been the experience of those consulted in this matter that the architect is most vitally interested in preparing his electrical plans in such a form that he may convey to the electrical contractor the exact nature and extent of the work to be installed. The architect is not so much concerned with the adequacy of the lighting as he is in covering the scope of the work, in connection with the wiring system, in proper electrical terms, so that it may be readily understood by those bidding on the work, and convincing to the owner that the job is complete. If assistance can be furnished in this respect he will more readily turn over the entire job of the lighting to the specialist and the responsibility as to its adequacy is then in competent hands. The problems of lighting and wiring are so interrelated that they cannot be handled separately.

Another point of contact of vital importance is that of the electrical contractor. In many cases where an architect is not employed the electrical contractor is the sole advisor of the customer, and very seldom has he had any special training in lighting design practice.

Much educational effort on the part of the central station company and the industry as a whole is necessary to establish in the mind of the electrical contractor that there is a problem in connection with each lighting installation which should be carefully studied by a man especially trained in this work. In localities where contractor associations are established, the lighting specialist may find a partial solution of this problem in presenting his story through the association and soliciting its cooperation. It should at least be made known to the contractor that the central station company in his vicinity is at his service to prepare lighting plans for his customers.

Other vital points of contact are consulting engineering firms, maintenance engineers, and office building managers. It should be uppermost in the mind of the lighting specialist that he must promote close cooperation with these men and establish with them this department of service so that they will use it freely whenever lighting problems are involved. Usually they have been forced to rely upon their own resources, having no such service at their disposal, and some time will be required to convince them that the central station companies are concerned with their problems. Once this fact is established the specialist will find himself constantly in the midst of lighting activities and his work will undoubtedly prove profitable to his employers.

Personnel Problems

There has been considerable discussion as to the best method of securing and training specialists for this work. The Lighting Service Manual, a serial report published by the Lighting Sales Bureau, N.E.L.A. 1926-1927-1928-1929, offers a very complete outline of methods for organizing service departments and of conducting sales campaigns. The manufacturers of Mazda lamps conduct training ocurses in lighting at intervals throughout the year especially for central station men. The Industrial Lighting Fact Book, prepared by the Industrial Lighting Committee, N.E.L.A. November, 1926, also contains many valuable suggestions along the lines of promoting and conducting sales campaigns.

A survey of store, office, and factory lighting in any community will immediately determine a field for sales.

It has been the general experience in this section that it is the best method of organization first to establish the department—that is, to employ one or more trained specialists and have them gradually develop sales as they develop capacity through experience. As the scope and volume of the work increases they may later train assistants if needed. There has also been much discussion regarding the seasons at which time new business in this field may be most easily secured. While business of certain nature may be secured more readily at certain seasons, it is found that the problem of lighting dovetails itself into the general problem of better merchandising and improved industrial operation throughout the year. There is in reality no regular season.

Study of Costs Needed

In conclusion the committee recommends to the succeeding committee that this study be continued further with a view of determining the proper expenditures to be made in order to gain this very desirable business and also in regard to educational work which may help the whole movement. Since the earnings per kw.hr. in lighting are higher than in any other class of load obtained and since the capital investments to obtain the business are in most cases considerably less than required for any other class of business obtained there can be no doubt as to the desirability of the load.

Street and Highway Lighting*

FOLLOWING the lead of the N.E.L.A., the street lighting committee is presenting herewith the last of a series of three reports begun in 1927. The first and second reports dealt with the desirability of the street lighting load, its large possibilities for immediate development, and some of its financial aspects.

This report deals with selling street lighting and with sales methods or plans. Its spirit, therefore, is not primarily to give data concerning street lighting possibilities, but to advance suggestions by which it is believed increased and additional street lighting may be realized. It presupposes that the street lighting load already has been established as worth while.

Without meaning to cast any disparagement upon preceding reports, the committee doubts that this fact actually has been established in the minds of the power company executives and others. No very active effort is being displayed in this field of load building. We read, hear about and see campaigns for the sale of all kinds of appliances whose ultimate end is load building. Salesmen are threading themselves actively and energetically through industries for the same purpose. But where is a like campaign to sell street lighting? We are persuaded that the sales resistance, or at least the sales indifference lies mainly within the minds of the officials who are directing the energies of their organizations in securing added revenue.

This committee believes that first of all there should be some definite steps taken to sell the street lighting idea to the directing officials. In other words, they, first of all, must be "sold" on the value of the street lighting load, and its characteristics; that street-lighting really is a salable commodity; and that there must be a definite allocation within a company of the responsibility for handling street lighting. A typical example of what can be done is found in The Public Service Company of Northern Illinois. One of the vice-presidents of that company became intensely interested in street lighting and organized a special street lighting department. An aggressive sales campaign to increase the size of the lamps used in the communities which they served resulted in the average candlepower of all street lamps served by the company being increased from 131 to approximately 170 candlepower. This made a decidely favorable impression on the systerm's load curve when it is considered that this company serves some 18,000 street lamps.

Let us remember again that it was street lighting which really started the electrical industry. The first power plant was built to serve street lighting units. That the load really is desirable and valuable.

Leaving out a phase of selling, which may be called just "order taking"—business gained with little energy or expense—in every successful sales transaction are found the following elements: (1) A customer; (2) Article being bought and sold; (3) A salesman; (4) Financing; (5) Sales campaign or plan.

These are considered separately in the following paragraphs.

Customer

The customer is the property owner, with his inherent spirit or desire for progress, conveniences and increased values. The city council may carry on the negotiation exclusively, may sometimes even initiate the negotiation, and may exclusively select equipment, but the customer really is the one who pays the bill—the property-owning tax-payer.

Some individual citizen with energy and optimism, or some fraternal body, or even the city council may be the spokesman, but unless the ones paying the bill are aroused to active desire, the sale will not be accomplished successfully.

(1) The Customer's Requirements Increased Sizes of Lamps.—Efforts should be centered upon selling service for lamps of not less than 250 cp. A lamp of 100 cp. or less is no more than a street marker and has little utilitarian value in these days of fast-moving traffic. About 10 per cent of the rates for these lamps represent energy charge and 90 per cent are fixed charges. Anything less than a 250-cp. lamp therefore is uneconomical to the city, because too great a proportion of the annual street lighting cost to the city is made up of fixed charges on the installation and only a relatively small part of the expenditure goes for the production of light. It also is unprofitable to the power company. Think of the effect upon a load curve, should all 100-cp. lamps or less be raised to 250-cp. lamps.

(2) Additional Lamps.—New whiteway systems, a lamp at every street intersection, and alley lighting offer openings for productive effort. The modern practice of building garages on the back of the lot approached by an unlighted alley is a hazard to the safety of the property owner. Dark alleys invite the attention of the hold-up man and afford a ready means of escape for the thief.

(3) Rehabilitation of Old Systems—Many antiquated systems now afford a loss to the power companies and to the city. Also, civic pride calls for their rehabilitation.

(4) Highway Lighting.—In most of the states within the confines of the Northwest Electric Light and Power Association there are thousands of miles of excellent paved roads. There is no one other thing which might be done that would be quite so valuable to impress the great tourist traffic as the lighting of these main highways. Some of the other advantages are:

(A) The prevention of accidents by making highways safer.
  (a) By showing up dangerous curves.
  (b) By reducing headlight glare.
  (c) By illuminating signs calling attention to side roads and obstacles.
(B) Protects motorists and discourages hold-ups and vandalism.
(C) Increases night traffic, thus relieving day congestion.
(D) Decreases running time and increases road capacity.
(E) Helps to bring electricity to the farm.
(F) Increases real estate values:
  (a) By tending to expand the city along the highways.
  (b) By extending electric service and the resultant conveniences.

("Highway Lighting—What It Means to General Business and Farming Communities," by J. B. Johnson, vice-president, Ohio Public Service Company.)

The greatest obstacle at present to highway lighting is that there is no means provided by our laws to finance the installation and maintenance. This committee therefore recommends that:

(A) A campaign be launched in as many states as possible within the boundaries of this organization for the purpose of laying the foundation for the introduction of a bill in the legislatures making possible such financing.
(B) That a bill be prepared and introduced.

Analysis of the Market.—If the power companies should actively and energetically seek to meet their customer's needs and desires for better street lighting as

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* Report of street and highway lighting committee—**H. S. Atwood**, Puget Sound Power & Light Company, chairman. **Dwyer & Rhodes Company:** J. G. Stuart. **General Electric Company:** Geo. N. Barker. **Idaho Power Company:** J. W. Crowe. **Pacific Power & Light Company:** G. L. Corey. **Portland Electric Power Company:** T. W. Fitch. **Utah Power & Light Company:** L. B. Gawan. **The Washington Water Power Company:** L. V. Ross. **Westinghouse Electric & Manufacturing Company:** Geo. N. Boyd, F. W. Jordan.

represented by a per-capita expenditure, there is the possibility of adding $1,750,000 additional revenue annually in the states of Utah, Montana, Idaho, Washington and Oregon. A great proportion of this revenue is obtainable with little additional investment in the smaller towns by simply selling the idea of the value of larger lamps.

Using Table 1 in the 1928 report of the street and highway lighting committee of this association (1928 Proceedings, p. 86) as a basis of calculation it is found that:

The 254 cities of from 1,000 to 5,000 population now pay annually for their street lighting service	$ 559,068	
At the minimum recommended, $2.50 per capita, they would pay annually	1,429,000	
Or an annual increase of		$ 869,932
The 47 cities of from 5,000 to 20,000 now pay annually	391,961	
At the minimum of $2 per capital they would pay	726,580	
Or an annual increase of		334,619
The 7 cities of from 20,000 to 100,000 now pay	147,700	
At the minimum of $1.75 per capita	369.498	
Or an increase of		221,699
The 3 cities of 100,000 and more (not taking into consideration Seattle or Tacoma) now pay	553,230	
At the minimum of $1.50 per capita they would pay	922,050	
Increase		368,820
Total increase		$1,795,070

It should be stated in this connection that there are several cities of from 1,000 to 5,000 in the Northwest which are paying approximately the minimum per capita recommended. Also that there are a large number in each of the other classifications in the Middle West and Eastern sections who either equal or exceed the minimum per capital recommendations.

The Article Being Sold and Bought

In a sales promotion, naturally it is impossible to ignore completely the element of selfish benefit to the seller—the power load to the power company, the equipment to the manufacturer, and the labor to the contractor—yet none of these is really the article being sold and bought.

The article is really **A Public Benefit—Light.** There are enough cases on record where the customer has asked for such a benefit without being solicited by any of the parties mentioned above to prove this point. This benefit naturally cannot be gotten to the public without the equipment, the labor for installing same, and the electrical energy, or power load.

With the power company as the leading salesman—assuming the greatest responsibility—and with labor and equipment being essentials, what attitude shall the power company assume toward the equipment and labor? Shall the power company own the equipment? Shall it recommend any particular manufacturer's equipment? Shall it install, or supervise, or act in an advisory capacity over the labor?

It is believed that sales promotion work will be clarified and sales increased by the practice of the following:

(1) Customer ownership of street-lighting equipment should be encouraged. Does the policy of bringing the proper voltage to the lighting equipment of individually owned homes and stores offer proof and precedent enough to establish the same policy for muncipally owned lighting equipment?

When the customer owns the equipment, a large amount of capital is released for other purposes more naturally and more intimately associated with the power companies' objective—delivering power for customers' consumption.

Municipally owned street lighting equipment does not necessarily encourage or speed up municipal ownership of power producing plants. Observation tends to show that that which will retard municipal ownership is excellent service and reasonable rates, rather than, the power company's owning the street lighting equipment. When the power company owns the equipment the rate established must necessarily include not only the rate for the electrical energy, but the amortization of the investment as well. This has a great tendency to increase discontent.

The back-breaking load for a municipality in connection with street lighting is the yearly maintenance expense. When that maintenance expense includes charges for both electrical energy and investments, discontent is created in the minds of the citizenship, the great mass of which do not or are not able to analyze the situation fully. This discontent grows when the citizen finds that the adjacent city, which owns its own street lighting equipment, is, thereby, getting its street lighting at apparently a lower rate than his. This discontent take form toward the power company and thus is encouraged the desire to throw it out, install a municipal plant and reap what seems to be the extraordinary profits being realized by the company.

A street lighting system is an improvement and should be treated as all other improvements—the ones benefiting paying for same in proportion to their benefits. For the power company to own any part of the street lighting equipment without owning the whole has the possibility of bringing on trouble with the buyers of the bonds issued to pay for the system. It is recognized that there are possible situations where the power company, to enable the city to secure an installation, might aid in the financing as is done for the individual when he buys appliances on the installment plan. This practice should be the exception rather than the policy. The policy of encouraging customer ownership puts the financing on a sounder basis and makes the selling easier.

(2) The power company should be completely neutral as to manufacturer's equipment, advising only that reliable manufacturers be considered.

Manufacturers have devoted much time and capital to the development and production of street lighting equipment. There should be the greatest harmony between the power companies and the manufacturers, and their representatives should be given an absolutely free hand and full co-operation in the selling of equipment. Favoritism on the part of the power company or any move on the part of its employees which might be interpreted by a citizen as such tends to discourage other manufacturers' selling activities in that territory. There is need of increased sales efforts.

For the company to work outwardly or secretly for some particular equipment is not treating the customer fairly. Competition on equipment keeps prices nearer to their true level. Favoritism may result in the customer paying more for an installation than he should.

(3) The power company should not enter into competition with the contractor-dealers for the labor of installation.

To prevent the furnishing of defective equipment or improper installations, the passage of codes by the states governing methods of installation and quality of equipment should be urged. In the absence of such codes, the power companies should have published requirements, advisory service and co-operative inspection in order to see that defective equipment and improper installations are not made.

(4) The power company should include in its maintenance costs the electric energy, lamp replacements, painting and cleaning of glassware only. The city should be left to take care of all broken equipment. It is believed that by such an arrangement the power company will avoid a great deal of ill will and reduce its expense of maintenance. It has been found that when a standard has been broken, glassware shattered, or breakage has occurred due to some accident, the power company may incur some ill will should it be compelled to force collection for any such damage. The city can collect such claims more easily and surely. In most cases this element of rate making is more or less a guess. With it out of the calculation, the rate can be more accurately figured, most likely lowered thereby, and the power company is on a sounder basis.

(5) The Illuminating Engineering Society issues from time to time the consensus of opinion of leading illuminating engineers as to the standards of practice for street and highway lighting. This deals with recommended intensities for different classes of streets in towns of different sizes, the spacing of standards, the height of the lighting units above the street surface, the arrangement of lighting units, and the size of lamps. The power companies should go no further in their recommendations than those laid down by the Illuminating Engineering Society.

Summarizing—The article for sale is a public benefit which is obtained through electrical energy transformed into light by means of installed equipment. The power company should own only the necessary equipment to deliver the proper energy to point of connection with customer's equipment; should be absolutely neutral as to manufacturers' equipment; should advise as to defective equipment and proper methods of installation; and should maintain and distribute complete information on the standard practices of street illumination.

Salesman

It is indisputably recognized that the largest factor in any sales transaction is the salesman. We should, therefore, establish who the salesman really is or should be in this street lighting proposition. Let us remember again that in this report we are not dealing with the selling of equipment or its installation but with the idea primarily of a **community benefit** in the form of better illuminated streets.

Of the three parties— the power company, the manufacturer of equipment, and the contractor—involved in every street lighting transaction, it is believed that it may safely be stated that most of the promotion and selling of the street lighting idea has been carried on by the manufacturers of equipment. This is not as it should be. It is believed that if the power company were to take the lead, street lighting would be greatly increased.

The power company ought to be the salesman, at least the leading salesman, on the job, because:

(1) It has more to gain. The electrical energy repeats itself year after year. In every "whiteway" system the power company's yearly return is approximately a sum equal to one-third of what either the contractor or manufacturer obtains in the installation. In three years the power company will have received a sum equal to either the contractor or manufacturer. In the overhead or utilitarian lighting, the power company's proportion is ever larger.

(2) It is more closely in contact with every possible street lighting sale by reason of the location of its employees and services.

(3) It should be more interested to improve the civic conditions in the towns served.

(4) With every sale of street lighting, increased show window and store lighting are encouraged. The adjacent city is tempted through competition and civic pride to improve likewise and the cycle of increased lighting is started all over again.

The selling function should be lodged within the commercial section and should consist of a group specially trained and organized to sell and handle street lighting.

The manufacturing company should be the assistant salesman because (1) it has equipment to sell and (2) it carries on research and study in efficient lighting and harmonious forms of equipment.

Financing

Expense of Selling—Expense of selling between parties involved in the sale, should be divided in proportion to total revenue obtained.

Selling Price—In establishing rates for maintenance the first consideration should be, naturally, a reasonable return on the investment in order to give proper service. However, this rate should be influenced by the fact that the majority of the demand is on the off-peak load; that the demand is constant and uniform; that there is little expense and no trouble from collections; that increase in street lighting will result in other lighting sales which can and should be more profitable; and that there is an advertising value—legitimately charged to advertising expense—in a well lighted city. The power of well lighted streets to add to the population is a well established fact. This in turn adds to the power load.

In making up the service charges, or selling price, the idea should be kept in mind that a good and well maintained street lighting system is a "business-getter." Costs should be kept as low as possible consistent with good business and electrical practice so that sales resistance may be reduced.

Cost for energy and maintenance might well be expressed in terms of per capita expense in addition to that of per lamp expense. It would be well even to reduce this per capita expense idea to a per capita expense per month. Comparative per capita expenditures for other purposes are illuminating:

Annual per Capita Expenditures:

Chewing Gum	$ 0.48
Ice Cream	2.32
Soft Drinks	3.33
Jewelry	4.75
Cigars	4.86
Cosmetics	7.25
Tobacco	7.62
Cigarettes	7.63
Automobiles	19.06
Resorts	28.58
Food Luxuries	47.62

Costs for installation might well be expressed in terms of cost per sq.ft. of area illuminated for each property owner. As for example, a 50-ft. lot on a 60-ft. street where the cost if installation is $2 per front foot, expressed in per-sq.ft. cost, is only 10.33 cents.

Financing the Sale—Overhead installations are paid for by city councils according to present practice, out of the general fund. It is so financed because city councils and citizens as a whole are thoroughly convinced of the necessity for lighting. In most cities the demand for street lighting units, especially at street intersections, is larger than the city's general fund can support. Ways should be advanced by which the general fund may be increased. A study of a city's budget often reveals that monies may be transferred from less needed and generally valuable purposes to the more needed and generally valuable purpose of street lighting. These ideas should be gotten across to the city council through a "key man" or other proper channel.

The installation costs of ornamental systems as a general practice throughout the territory are assessed against the abutting property. Payment is made by bonds. In order to initiate an ornamental system it is the usual practice for the property owners to petition the city council. The city council prepares costs, advises property owners, gives opportunity for protests, prepares specifications, calls for bids and lets contracts.

A reliable engineer's cost should be obtained at the outset in connection with every installation.

Sales Plan or Campaign

It is admitted that no one sales plan can be applied to all situations, but it seems that a certain general outline may be used as a guide.

From the foregoing we draw certain general conclusions:

(1) That the idea to be sold is the benefit derived from a comprehensive street lighting system with its proper intensities and arrangements for each class of streets. This means more and larger lamps for overhead or utilitarian lighting (here lies the largest opportunity as this class of street lighting comprises about 90 per cent of the present street lighting load and possibilities), new "whiteway" systems, and the revamping of antiquated systems.

(2) The power company should first sell itself on the advantages of street lighting and then organize for effective merchandising of street lighting benefits.

(3) The property owner is the one that must be interested and sold.

(4) That the campaign must center itself about the advantages to the city of a well and completely designed street lighting system.

We have seen no better and more concise outline of effective merchandising of street lighting service than that which has appeared in the proceedings of the N.E.L.A., as follows:

(1) Realize—

(a) That street lighting is a salable commodity and that the installation of an effective street lighting system is the logical approach to better window lighting, to increased intensities in store lighting, to more and better street lighting in other communities which later in turn starts a new cycle of complimentary lighting.

(b) That the public interest requires street illumination many times greater than the present values and for their attainment justifies public expenditures at least twice the present average expenditures. It is generally conceded that in the average American city an annual expenditure of not less than Two Dollars per capita is justified by its return in decreased accidents, decreased crime, increased convenience of urban life, and increase in property values.

(2) Organize for the Effective Merchandising of Street Lighting Service—

(a) By making the commercial department responsible for the sale of street lighting service.

(b) By building up in the commercial department a lighting service division equipped to render up-to-the-minute service on street lighting problems.

(c) By selling the advantages of the street lighting load, and its value as a "good will builder," to all central station employees, and by keeping street lighting before them at all times.

(d) By thoroughly surveying the possibilities for street lighting development separately and in detail for each community served. This survey to include the determination of the individuals in each community who are best able to combine an ability for civic leadership with an unselfish interest in civic advancement. Such individuals may not of necessity be in public office.

(3) Assume Leadership In Promoting Adequate Street Lighting—

(a) By demonstrating the desirability of each community adopting a completely engineered "ultimate plan" definitely establishing all physical elements of a street lighting load system which will provide adequate street lighting service, including satisfactory appearance, at the minimum cost consistent with such service.

(b) By keeping the subject of good street lighting before civic societies, business men's clubs, chambers of commerce, safety organizations and women's clubs.

(c) By selling the advantages of good street lighting to the newspapers and keeping them sold.

(d) By advertising the value of good street lighting in the newspapers.

(e) By using appropriate window displays, exhibits and signs advertising improved street lighting service.

(f) By compiling data showing the effect of good and poor street lighting in local communities and elsewhere.

(g) By using "before" and "after" photographs of typical street lighting installations.

The committee adds the following:

(h) By definitely organizing a committee of influential property owners to secure signatures to petitions and presenting this committee with a list of the property owners showing exact manner in which signatures must be obtained.

(i) By timing the campaign to coincide with local situations and making it as brief as possible.

The manufacturers are in a position to furnish envelope stuffers, newspaper mats, booklets, show window displays, color cards, outlines of talks, motion pictures and delineascope films which sell the street lighting idea and not their equipment. The manufacturers are in a position to offer other sales assistance and engineering data.

The whole campaign should be conducted with the idea of getting "the signature on the dotted line" rather than just indefinite talking.

Electrical Advertising*

THE SCOPE of this electrical advertising committee is roughly as follows: "To gather data on the use of electricity in signs, posters, floodlighting and window lighting in the Northwest territory; to gather statistics relative to the available field of such business; and to formulate plans for securing this business in communities of all sizes." These several aims have been kept in mind in the preparation of this report, and while statistics and definite working plans may be somewhat meager, nevertheless, it is felt that the report gives a bird's-eye view of the present field and the possibilities for future development.

A very enlightening and interesting analysis of the present condition and possibilities of electrical advertising is contained in an article by John F. Gilchrist of the Commonwealth Edison Company in the February, 1929, "N.E.L.A. Bulletin."

Among other things he brings out the fact that the total advertising bill for the entire country amounting conservatively to $1,300,000,000 is more than all the money paid to the utilities for electricity in the entire nation. He estimates that electrical advertising accounts for perhaps five per cent of this figure, or $65,000,000, and that if this electrical advertising could be increased to $200,000,000 where at the least consideration it should be, the increase from this source alone would amount to over ten per cent of the electric utilities' entire income at the present time.

Advertising comes within two general classifications; first, circulating advertising, and second, display advertising. Circulating advertising is that comprising magazine and newspaper advertising, advertising which will await the leisure of the reader to peruse. Display advertising, however, is fixed in its place, and must get attention quickly. Electrical advertising belongs to this second class. While circulating advertising may be argumentive, and may employ reason, display advertising must be simple, striking and impressionistic. It must appeal to the senses. There is a large available field of this electrical advertising business and the cost of obtaining it is not excessive.

Electrical advertising offers a wonderful channel through which the utilities can help customers build up their business to the mutual advantage of customer, utility and the town itself. Proper attention, however, must be paid to the location values of the advertising medium, and we should at all times strive to have it a neighborhood asset. It should also be simple in its message.

The Electric Sign

The electric sign business appears to have fallen into disrepute in late years, perhaps because too many of the sign salesmen were merely "solicitors", or of the high pressure type who were more interested in making the sale of the sign than they were in the welfare of the merchant who was buying the sign. The wrong type of sign or the wrong size was sold. In 1918 we recall that the sign business was just getting into a good stride and much sign load was being added. Also about 1918 came the World War. The man power of the utilities was immediately curtailed due to enlistments, and the new business activities were practically discontinued. The full facilities of the utilities were immediately directed towards the task at hand of keeping up with ever mounting war time demands for power. Electrical advertising suffered a serious relapse when it had appeared headed for great development. We have now come to a point of resurrected interest in electrical advertising and are again appreciating to some extent what a very desirable class of business it is.

There are two phases of development for this business; first, selling the idea of electrical advertising to the customer; and second, the selling of the particular advertising medium. The power companies can well afford to do this initial development work as there is much load to gain and a sales organization already exists. The manufacturer of signs who must rely on actual sign sales for his operating revenue cannot afford the time for the missionary work. Here is the place for the cooperation between the utilities and sign manufacturers which is indispensable to the fullest exploitation of the field.

Survey of the Sign Field

There is a tremendous load available in electrical advertising, probably 100 per cent as a minimum increase over that enjoyed at present. In an eastern city, a recent check of sign users found that 32 per cent of the cafes used signs, 39 per cent confectionery stores, 20 per cent clothing stores, 11 per cent general merchandising stores, 90 per cent drug stores, and 54 per cent retail automobile establishments were using signs. A recent check of seven blocks on a principal street in Portland revealed the following percentages, which vary somewhat from those first listed: Haberdashery stores, 63 per cent; drug stores, 80 per cent; shoe stores, 63 per cent; jewelry stores, 53 per cent; cafes, 84 per cent; confectionery stores, 57 per cent; clothing stores, 57 per cent; cigar stores, 70 per cent. Of these, 58 per cent were Neon signs. These percentages represent those whose electric signs were lighted. A check of your own city or the application of these percentages to the number of establishments of the different kinds will show the additional business available in any locality. In the entire country, it has been estimated that there are 425,000 electrical display signs. Of 3,000 electric signs recently surveyed it was found that 1,921 were exposed lamp signs, 576 interior illuminated signs, 500 reflector arm signs, and the balance other types.

Developing a Selling Program

The sign manufacturers have for some time questioned whether or not they are working in the close harmony with the utilities necessary to secure the sale of the largest number of signs. There are indications that they will seek closer cooperation, and when they do, it will be well worth the utilities' while to detail a man or men to work with them in developing this business. Whether it will be "a man", or "men" will depend entirely upon the size of the community. A most potent means of developing sign business, however, would be for the power companies themselves to use electric signs wherever possible, and show the world that they believe and practice what they preach, that they realize the advertising value of electric signs in their own business as well as in the business of the customer whom they are trying to interest.

There are two fundamental things for the utilities to do to carry on this electrical advertising program, and they are: first, to establish a definite means of handling the business; and second, to detail a definite department in large cities, or a particular man in the smaller places and make him responsible. The time payment idea can be utilized in sign sales and will lessen the sales resistance materially.

The cost of electrical advertising to the advertiser is quite small compared to other media, and the customer should be sold in terms of "electrical advertising" rather than in terms of "electric sign." For instance, $2,000 worth of electrical advertising will convey a definite meaning to him while $2,000 worth of electric sign will not. He is not interested in buying an electric sign. What he wants is the electrical advertising. He does not buy all printed pages on which his advertisements appear, but he buys the increased sales resulting. A careful check of depreciation cost and circulation of several signs owned by the General Electric Company shows that the cost averages about $1.00 per thousand persons contacted. For a one page ad in black and white in the Saturday Evening Post, the cost approaches $2.95 per thousand. Street car cards about $1.20 per thousand. Newspaper rates are based on a rate per thousand of from $3.80 to $5.04 in the large metropolitan dailies. In very high circu-

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* Report of electrical advertising committee—**T. W. Fitch,** Portland Electric Power Company, chairman. **Electrical Products Corporation:** Bruce McGregor. **Graybar Electric Company:** Blair E. Plowman. **Northwestern Electric Company:** A. K. Gaylord. **Puget Sound Power & Light Company:** N. W. Brockett, A. G. Gordon. **Utah Power & Light Company:** K. W. Browning, George Ellerbeck. **The Washington Water Power Company:** L. V. Ross.

lation areas, such as Times Square, the cost of electrical advertising easily falls to from 7 cents to 25 cents per thousand persons contacted. The use of electric signs is on the increase throughout the country, as is indicated by a 16-1/3 per cent increase in sales of sign lamps by one utility. Some figures received from Northwestern cities show the following average increase in kilowatt-hour consumption from electric signs for the past three years:

Increases in Electric Sign kw.-hr. Consumption

	1926 over 1925 Per cent	1927 over 1926 Per cent
Everett	25	6
Seattle	22	15
Wenatchee	270	10
Tacoma	20	15

Salt Lake City goes back a year or two further and shows the following:

	Per cent
1924 over 1923	265
1925 over 1924	13½
1926 over 1925	15
1927 over 1926	1½

The Neon Sign

The Neon sign has practically dominated the sign field for the past year, and bids fair to continue to do so. The first Neon signs appeared on the coast about three years ago, and now appear everywhere—sidewalk signs, building top signs, and mammoth hill-top signs with letters sixty feet high. In Portland there are 710 Neon outdoor type signs in operation with a Neon kva. of 1.086. The advent of these signs and their rapid spread involved the utilities in the consideration of the poor power factor feature of the Neon signs. This power factor averages about 42 per cent for straight Neon tubing. When used in connection with incandescent lamps, the power factor becomes better. Even with straight Neon tubing the power factor can be increased to any desired value by the use of low voltage capacitors, or high voltage condensors. In cases of straight Neon tubing for building outlining purposes, it may be necessary to insist upon a definite power factor correction. It has been recommended in some quarters that this figure be 90 per cent. The use of either capacitors on the primary side of the transformers, or condensors on the secondary side will accomplish this result. It appears at present that an investment of approximately $60 to $75 in low voltage capacitors will correct the average Neon sign of 950 volt-amperes and 408 watts to a 90 per cent power factor. The cost of correction on the secondary side is not available. Experimental work indicates, however, that high voltage correction will be less expensive than low voltage correction providing a better type of transformer is used. In other words, the high voltage correction necessitates much better transformer insulation than low voltage correction.

From these facts it would seem to follow that power factor correction of existing installations had better be by low voltage capacitors to avoid transformer failures, but that correction of new installations might be more economically obtained by use of the high frequency condensors. A considerable quantity of data on present power factors of Neon signs has been obtained.

The use of incandescent lamps with the Neon tubing, is in the opinion of this committee, the "Moses" which will lead us out of the wilderness. The straight Neon sign has a garish effect. The emanations of Neon light are monochromatic in character, and for that reason, while being spectacular, they are tiring to the eye. Any fixed color is tiring to the eye after 14 or 18 seconds, and we instinctively turn away from it. The use of incandescent lamps in connection with the Neon tubing has a very softening effect and such a combination sign stands out quite favorably with the mass of straight Neon signs now on the streets. Then too the straight Neon signs do not lend themselves to movement, one of the prime requisites of good display. Incandescent lamps do so lend themselves, and with the use of flasher circuits can provide moving color. The new S-11 intermediate base lamp with the inside coloring is destined for a tremendous use in providing the mobile color so essential in modern effective signs. It appears that the Neon people are well aware of this fact, so it seems that some form of "natural selection" will take care of this poor power factor bugaboo of the Neon signs. The Neon sign, although of very low power consumption, is a steady load, 24-hour for the most part, and this 24-hour load makes up in some degree for the relative low wattage consumption.

The advent of the Neon sign has had some interesting reflexes. It is next to impossible at present to sell an exposed lamp sign in any of the larger cities, as Neon is the thing of the moment and anything else in highly competitive territory is a back number. However, in smaller places, the incandescent sign manufacturers have found the field for their wares considerably bettered by the Neon salesmen. The higher price quoted for Neon signs has boosted the average merchant into a receptive attitude for a much better incandescent sign than he would have previously considered. The Neon sign may be too expensive for him, but the better incandescent sign is not. This means, perhaps, that larger and better incandescent signs are being sold in the smaller places where the rates for electric energy are usually higher than in the larger cities.

Bill-Boards

Electrically lighted bill-boards and posters are familiar to us all. In Portland there are about 770 lighted bill-boards operated by one company alone. The poster companies maintain a highly efficient sales organization of their own and they are not letting anything pass which will bring additional revenue to them, and if they can see where a lighted poster will bring them more revenue, they will light it. In certain small communities they cannot get the additional return from a lighted board to warrant the additional cost of operating it, so there are some boards which it is not feasible to illuminate. Of these 770 lighted boards in Portland, 13 of them have Neon tubing to bring out a condensed message. The sign companies prefer to determine themselves how much Neon should be used on a bill-board as they have definite ideas of balance and values. They utilize the Neon tubing merely as a periodic change in design. Lighted posters have increased somewhat in the past two or three years, as evidenced by the following figures:

Increase in kw.-hr. from Illuminated Posters

	1926 Per cent	1927 Per cent	1928 Per cent
Seattle	20	17	Not Available
Atwood	14	12	Not Available
Wenatchee	0 to 6,048 kw.-hr.	1,200	Not Available
Tacoma	0 to 3,000 "	100	Not Available
Portland	11	9	6½

Window Lighting

Window lighting has come in for considerable treatment in late years by the lamp manufacturers, equipment manufacturers, the N.E.L.A. and other interested bodies. The elements of good window lighting are so well known that they will be only lightly touched upon here. Window lighting has been advancing from the old level of one bare lamp to the present level of multiple rows of high power units with proper reflectors, augmented by spot and window floods, and in many cases colored lighting. The kw.-hr. consumption has shown a steady upward trend, the larger cities showing the smaller recent gain due perhaps to earlier development of the field, the smaller cities showing relatively larger gains. A brief tabulation follows:

Kw.-hr. Increase from Window Lighting

	1926 over 1925 Per cent	1927 over 1926 Per cent
Seattle	4	8
Everett	22	4
Wenatchee	28	10
Tacoma	20	25

The double decked windows have come into some popularity in the East and in the West. In the East the merchants are not so well sold on the value of the double-decked windows except where double-decked buses are used, serving to raise the eye up to the level of these upper windows. In the West, however, double-decked windows appear much better thought of, especially in cities having narrow streets, where they can attract the passers-by from across the street, thus making their direct value even greater. Cities having wide streets might be restricted to those benefits ob-

tained from double-decked buses only. In either type of city, however, the added indirect benefits derived from the physiological drawing power of light itself in diverting traffic and in impressing the name or a location is made effective some distance away by the larger block of light presented by the double-decked windows. Upstairs stores for several years have utilized second story windows to display their suits and wares. These windows have drawn attention from across the street, also from offices in buildings opposite, up to the sixth or seventh stories. Inasmuch as they are at a disadvantage in the point of distance from which they must draw attention, it is advisable that they be lighted to a higher intensity, if anything, than the first story windows.

Super lighting derives its main value from the physiological attraction of bright lights, nevertheless, it pays. A dazzling window is not artistically so pleasing as one of more moderate intensity, but it certainly pulls and has "halt-power." A recent test conducted by the Tennessee Power Company showed a 93 per cent increase in attraction power from a super lighting installation which consisted of additional 500-watt units on 2-ft., 4-in. centers. Care must be taken, however, that harmful effects do not result to the goods being displayed by reason of the excess heat generated. A moderate super lighting installation might consist of 500-watt spot lights spotting out the leading articles. Auto sales rooms are very good prospects for super lighting, as there good lighting is recognized as an adjunct to selling.

The window must be regarded as a stage and must utilize stage methods of lighting if it is to compete for attention successfully. Two new developments in window lighting are the foot lighting, which softens the shadows from the overhead lighting, also displays certain features of the lower part of the article itself, such as ranges, tables, davenports, etc.; and the use of color. Color, however, must be considered from an advertising standpoint and not entirely from the angle of artistic satisfaction. The use of colored drops for backgrounds in windows achieves a very pleasing and effective compromise, or rather amalgamation of the two ideas which must be kept in mind. Under colored light, details cannot be brought out in the gripping manner necessary, but with a colored background against which the white lighted articles in the foreground can be set off, we get the artistic effect of color, with the good advertising effect of white light on the object itself. The back drops are lighted by an entirely independent row of reflectors at the back of the window, hidden from view by valences. The colors must be of sufficient wattage so that the white light in front will not wash out the colored effect. A very effective window might be of objects spot-lighted on black velvet flooring, with a brilliant green background, changing perhaps to a brilliant red or gold. Brilliant colors are necessary to hold their own with black; softer tints can be used with tinted or colored floors or trim material. All of this uses more kw.-hr.

A later development of the use of electricity in display is the use of mobile color. As has been said in discussing Neon signs, fixed colors become irritating after 14 to 18 seconds, but a modulated color series retains its charm. An interesting check of the relative effectiveness of fixed color and moving color, also of plain white light was obtained recently in the East. The merchant, whose windows were being used for the test, had been using color caps for some time, and would not permit their removal even for that period of the check for white light values. as he thought he would lose too much business. Therefore, only one white light value was obtained and this was from a competitor's window. The check was made keeping in mind four features of the actual attractive value of a window:

Mobile Color Stoppage Values in Show Windows

1. Number of passers stopping:	clear light	3.64 per cent
	fixed color	10.4
	moving color	11.9
2. Number of passers entering:	fixed color	1.2
	moving color	2.15
3. Number of passers who buy:	fixed color	.79
	moving color	1.35
4. Revenue per passers:	fixed color	1.08 cents
	moving color	1.6

Daytime reflections are a bug-bear to merchants and these can be overcome most effectively by using a higher intensity of light in the daytime than at night. The intensity can be varied to suit the brightness of the day. A window is always a mirror on the side of the greatest brightness to the extent of the relative brightnesses on the two sides of the glass. It has been suggested that colored light be used as a means of overcoming the loss of value due to daytime reflections, but this idea has not been worked out fully as yet. It would apparently take a much higher wattage of colored light to overcome the white light outside, inasmuch as the colored light is only a portion of white light. Five hundred-watt spot lights would serve to spot out some article or portion of the window even on bright days, and would stop many passers-by who otherwise would not be stopped. This phase of window lighting presents a field for considerably greater current consumption, and it is suggested that the problem be attacked by either persuading some large store to try it out in one of their bad windows, at their own expense or at the expense of the power company if necessary. The main thing is to show what can be done. Establishments featuring women's wearing apparel should by all means have good lighting in the trying-on rooms. Frequently dissatisfaction is expressed by purchasers who fail to get the same effect when goods are examined closely in the trying-on rooms as the effect which attracted them when the garment was viewed in the window. This is a case where the window does its job, but is not followed up by good interior lighting.

Additional revenues from window lighting are being further augmented by the ever increasing spread of "white-way" street lighting. Merchants must then increase their window intensities to retain the greater relative brightness. Tests are now being conducted in cities along the coast to determine the drawing power of various window intensities for different kinds of business. Of 3,200 establishments surveyed, it was found that the show-window installations varied greatly. Sixty installations were found to have 12-in. spacing; 84 had 18-in. spacing; 109 had 24-in. spacing; 197 had 30-in. spacing; and the rest were over 30-in. and non-standard spacings. Super lighting starts with 500-watt lamps on one foot spacing.

Successful Methods

A very remunerative use has been made by the Illinois Power Company of a yearly "dress-up week" featured by the citizens of DeKalb, Illinois. As it is usually the first week in October, they have capitalized it as a "light up your window" week, and the idea has been so well sold to the merchants that a gala occasion is made of it. A $25.00 prize is given for the best window, judged strictly from a lighting standpoint, and prizes are donated also for other features. The evening of the judging is a high spot in the year. The band comes out and the farmers come in. Boy Scouts direct the traffic, and a "good time is had by all." This is an idea which can be used in many small communities as well as in the neighborhood districts of larger cities. A great deal of additional load could be obtained. In larger cities, trial installations at as small an expense to the merchant as possible is perhaps the best way to interest him in better lightings. The financing of the installation by the utility with time payments by the merchant has also proved valuable as a means for putting over sales of bettered window lighting. Keeping "before and after" photographs of installations together with accurate data on stoppage values and traffic flow are very convincing. It would pay us all to start an album of photographs and such data.

It has been noticed at Salt Lake City that the remodeling of stores follows a rather regular cycle. Every four of five years a merchant will either completely or partly change the appearance of his store exterior. It was found also that during a like period many establishments change ownership, probably to a new business of a widely different character. In observing the above conditions closely and being ready at all times to follow a job, they are kept constantly in touch with this field of lighting.

Cost of Securing Lighting Business

The department of the public utilities which could best handle work of this nature is the lighting service

department, or as it is sometimes called, the illuminating engineering department. Practically all of the larger utilities have departments of this nature at present, and are finding them very satisfactory in the point of dollar revenue per dollar of department cost. It has been difficult to determine the actual tangible value of lighting service departments due to the fact that accounting department records are frequently inadequate in providing figures sufficiently specific for such information. A means of obtaining these data, however, has been worked out in one utility at least and it has been clearly shown that the average return in yearly additional revenue is somewhat greater than $3 for each $1 of department cost. This increase in the majority of cases entails no additional capital investment for the utility, and continues on the line indefinitely. Thus the $3 yearly additional revenue at $1 cost becomes $6 in two years, $9 in three years and $15 in five years. In other words, in this last instance, the additional revenue has cost only 6-2/3 cents per dollar. The intangible value of these departments in the way of public relations in their advisory work with residential and commercial customers is perhaps as great as the tangible value from increased revenues.

These remarks regarding lighting service departments are brought in at this time to show the value of such a department to a utility and how the work in connection with the development of electrical advertising comes logically within the scope of their activities.

Floodlighting

Northwestern cities have done considerable with the floodlighting of used car lots, refreshment stands, service stations, and building fronts using either regular floodlighting equipment or high-mounting outdoor units. In Portland one company made about 40 of such installations during 1928, averaging 1.1 kw. per installation. Each such floodlighting installation was thus equivalent to a good-sized residence in load and was in excess of a residence in revenues. Seattle has done much floodlighting of new homes during exhibition periods. This serves to dramatize the situation, framing the brightly lighted house against the blackness of the night. The real estate companies can either rent the equipment and pay a certain sum for each installation including installation and current, or else they can own the equipment and pay flat rate for current and a stated amount for each installation. The Portland Electric Power Company has no rental equipment for indefinite periods, but has been glad to loan the equipment at no charge for limited periods of short duration. In Spokane 500-watt floodlights are rented at 15 cents a night with a minimum of 90 cents, charging in addition for broken lamps. This does not include installation costs or current. Current is billed either at flat or meter rate. Floodlighting in Seattle has reached very satisfactory proportions, reaching 400,000 kw.-hr. in 1927 from a standing start in 1926. This 400,000 kw.-hr. would indicate a connected load of about 180 kw. of floodlighting. The 1928 figures are not available, but it is safe to assume that there has been a proportionate increase. In smaller localities floodlighting has not had the proportionate use. In Wenatchee for instance, 1927 showed only about 90,720 kw.-hr. from floodlighting.

That there is a tremendous field for the floodlighting of buildings goes without saying. Every city boasts a few buildings of a monumental and outstanding character which would lend themselves wonderfully to floodlighting. In Seattle the Medical Dental Building when lighted looms up like a white mountain on a black plain. The Twin-Wrigley Buildings in Chicago, and Roos Bros. in Oakland are notable examples of floodlighting, as are the Los Angeles City Hall and Cleveland Union Terminal Building. In Portland the Weatherly Building, Public Service Building, and the Odd Fellow Hall are lighted on the upper stories the Elks Buildings being floodlighted in its entirety. In Spokane the new Chronicle Building is illuminated. Before the advent of "White-way" street lighting on one particular street in Portland two bank buildings were floodlighted. The street lighting, however, destroyed the effectiveness of the floodlighting, and it was removed. The power companies are represented in the field of lighted buildings principally by the San Joaquin Power Company, Fresno, California. The Edison Building in Philadelphia, and the Public Service Building, Portland.

A good building floodlighting job should bring in a revenue of at least $400 per month. If the utilities would floodlight their own buildings, it would be a tremendous aid in selling other such jobs. There are many prospects to work upon, and as an advertising feature, good-will builder and a favorable attention getter, floodlighting has few equals. It is only at night that most of us have time to think about the architectural beauties around us, so when darkness falls, what better means is there for a firm to impress upon the populace their friendliness and progressiveness, or for a building management to bring out the architectural beauties of their building than with light? It shows a measure of pride and appreciation of their building. At present, if we were some night suddenly to extinguish all advertising signs in the city, the city would present a very drab appearance indeed.

The cost of a floodlighting job naturally runs into considerable money, requiring as it does frequently 400 floodlighting units. However, if it brings in a revenue of $400 per month, it is to our advantage to work out financing schemes which will make it easy for building owners to floodlight. The utilities might find it to their advantage to underwrite such an installation in return for a fixed minimum monthly bill. The advertising value of such an installation would be such that other advertising could be curtailed and the installation paid for in part from the advertising appropriation. At least, the carrying charges of the additional capitalization could be so handled.

The equipment used and location of equipment must naturally be determined by the character of the building to be floodlighted. The new set-back structures can have the equipment mounted upon the building itself. Some structures must be lighted from other buildings. Still others could be lighted by movable arms, which support the lighting equipment, these arms being lowered and raised by motor driven apparatus, lowered during the night for floodlighting, and raised during the day, so that the architectural features of the building would not be marred.

As mentioned before, the biggest aid in selling such a job is a notable example close at hand. If each power company's main building or one building at least in a conspicuous location were well lighted, other jobs could be secured far more easily. It is within the province of the utilities to show what can be done with electricity, just as much as it is the business of manufacturers of paint or glue, or the makers of Listerine and others to develop and broadcast more uses for their products. These Northwestern cities are fortunate in having hills on which are buildings well located for floodlighting. Churches, temples and schools are good subjects. Some good looking churches have plenty of money, and it might be possible to interest some wealthy member in a memorial floodlighting installation.

Spectacular Lighting

Artistic treatment is possible with many buildings. Colored light can be used in balconies, blue light for instance in the balconies of Masonic Temples, symbolizing the Blue Lodge. Mobile color lighting lifts even a floodlighting job out of the commonplace. Colored light alternating with white makes possible an endless variety of effects. For instance, several circuits bring first say a violet or a purple, then a very dim white coming on slightly tints the violet and finally washes it out entirely. During the full white, the violet is switched off and blue comes on. The white then gradually dims, presenting the full range of the tints of blue. As the white again becomes brightest, a green circuit flashes on, and the range of the tones of green appear. After the green comes the yellow, then the orange, then the red, then a magenta—each color in all its graduated tones. The color sequence must be carefully handled, so as not to bring a color too close to its complementary. Following the spectrum sequence has been found the most pleasing.

"The most beautifully illuminated business building in America" is the description applied to the John H. McClatchey Building in Philadelphia. Art glass pilasters are illuminated by hidden lamps. The fourth story is set back and bathed with thirty changes of color through six complete lighting systems. The modulation runs through red, deep blue, green, amber, light blue, and clear white. Ninety thousand watts in 573 reflectors are controlled by dimmers; 58,680 watts are used

in the art glass pilasters alone; 45,000 watts constitute a maximum instantaneous load.

Wonderful realism of effects can be obtained with the ingenious use of color with other aids. Sometimes, they can be too realistic. Recently a New York building was color lighted above the thirtieth story, red and green floods of 1,500 and 1,000 watts being used, and the effect was that of a furnace of red and green flame. This effect was further heightened by using revolving double color discs. When the effect of smoke and sparks was added, the total effect was so realistic that the fire department was called out. Thereafter that particular phase of the lighting had to be abandoned.

In Germany several noteworthy examples of light festivals have been held, one at Frankfort on the Main in 1927, and a more recent one in Berlin in September, 1928. Many buildings and statues were illuminated.

Church windows are excellent subjects for lighting from the interior, and are very effective both from an artistic standpoint and from the standpoint of church advertising. What better can symbolize the church with its peace and contentment, the beautiful stories and spirit, than can these beautiful story windows throwing their friendly warmth to the passer-by. Young people's societies in the church can be interested to the extent of financing such installations, as was recently the case in Portland when the large west window of the First Congregational Church was lighted. Portland has several lighted church windows and every city has some fine subjects to work on, works of art unseen at present. The installations vary in cost according to the inside architectural features, from about $75 upwards. Fifteen hundred to 3,000 watts is the usual capacity required. When memorial windows are being put in, get the lighting in as part of the memorial.

Floodlighting installations for small buildings, confectionery stores, used car lots and automobile establishments can be helped along by utility financing. A down payment of 20 per cent is sufficient with the balance in four to six months. Some companies add 10 per cent to the total cost of the job as a carrying charge. One company bills all such installations on a meter basis, as additional load where possible, and as a separate installation when necessary. It is against the policy of some companies to consider as additional load equipment fed from other points than that of the premises being lighted. One company requires a waiver permit when floodlighting equipment is permitted on the company's poles. This permit protects the company from any damages which might result in any manner from such an installation, and also provides that in case it is necessary to move that particular pole, the installation will be removed at the customer's expense.

The utilities can aggressively push this type of installation, as a load of from 1,000 to 1,500 watts usually results. It is also possible to encourage store owners on poorly lighted streets to get together and flood their store fronts from the roofs of buildings across the street until such time as white way street lighting arrives.

A new apparatus which has been developed projects messages onto the clouds. A reflector five feet in diameter is used with a spherical surface and long focus. The light source consists of a series of horizontal carbon arcs shaped in cross-section in the form of the letters being projected. The instrument is turned toward the clouds and adjusted for definiteness. Distances can be gaged by means of this instrument by setting the instrument for a particular distance and directing it towards the object in question. The definiteness of the image enables an estimate of the distance. Other equipment which has been developed consists of reflection units with 90, 180 and 360 degree spreads utilizing 7-element Fresnel lenses.

In Salt Lake City the majority of incandescent signs, bill-boards, floodlighting and window lighting installations are covered by a flat rate contract of two or more years' duration, providing for definite hours of burning, and which includes ordinary maintenance by the company. By this is meant, cleaning, furnishing lamps and turning the installation on and off at designated times by patrol within the commercial district and by switch in other parts of the city. This type of business is, of course, desirable from the utility's standpoint, as it insures a consistent use of current for definite periods. It is also attractive to the customer, as it relieves him of maintenance troubles and the expense of a watchman to turn off lights at night, and allows him to know at all times just what he is spending for light for advertising purposes.

To assist men assigned by the utilities to the development of electrical advertising load, the N.E.L.A. is bringing out courses of study on advertising and the various features connected with its exploitation. These courses will be available to whomever can go East to attend them, and will no doubt be brought out in pamphlet form for the benefit of those who cannot attend the school. There is so much additional revenue awaiting the utilities in the various phases of electrical advertising that it is well worth while to take steps towards the assigning of a particular department to handle it.

For further data on the various phases of electrical advertising, reference is made to the "Symposium on Electrical Advertising" which is the serial report of the electrical advertising committee of the Commercial National Section dated January, 1929.

The chairman wishes to thank the several committee members whose valuable data and assistance have aided materially in getting together the few facts and ideas embodied in this report. It is sincerely hoped that the work of this committee may be instrumental in arousing an appreciation of the possibilities for increased load from electrical advertising and that it may result ultimately in returning to the utilities some of this revenue which at present is being lost to them.

Home-Lighting Education*

PROPER use of electric light in the home is wholly a matter of education. There should be the right amount of soft, thoroughly diffused light. Bare lamps, glaring reflecting surfaces, excessive contrasts and heavy shadows should be eliminated. The light sources, fixtures and portable lamps should be placed properly with relation to the eyes. All this must be done to conform with decorations and personal tastes. The committee in an endeavor to spread this information in full detail to that person most directly interested in the home, the housewife, decided to present lectures on proper lighting before women's clubs, parent-teachers associations, and other groups of women. In this way the greatest number could be most effectively reached.

Equipment Used

A twenty-minute educational talk illustrated by charts and enlarged photographs was developed by Clark Baker, National Lamp Works, Oakland, Calif. In July, 1928, the committee constructed five complete sets of equipment consisting of four enlarged photographs 31x40 in., nine charts and diagrams of the same size, one collapsible easel, one 250-watt spot lamp, one glare lamp assembly and several small accessories. There is a specially constructed wooden case to transport each complete set. The accompanying illustration shows three of the thirteen charts and the several pieces of equipment as set up for the talk. One set each was sent to the member companies in Salt Lake, Walla Walla, Spokane, Seattle and Portland. The chairman coached a selected man in each of these places in the talk and demonstrations until he was thoroughly competent to make the presentation and carry on the work.

Arranging the Speaking Dates

A little difficulty was experienced at first in arranging the appearances in the schools before the parent-teachers groups. However in Portland the program president of the Federated Parent-Teachers' Association was given a private presentation of the talk and demonstration, and it immediately won her unqualified approval. Upon her recommendation there has developed a steady demand for the talk. There is not one

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* Report of home educational lighting committee—**Fred Zaugg**, Northwestern Electric Company, chairman. **National Lamp Company:** Walter Potter. **Pacific Power & Light Company:** H. C. McDaniels. **Puget Sound Power & Light Company:** H. A. Gardner. **Utah Power & Light Company:** K. W. Browning. **The Washington Water Power Company:** L. V. Ross.
Captions for NCL-1

thing in the lecture that conflicts in any way with the policies of the association. In the case of women's clubs and other groups, our program has been eagerly accepted.

Talks Given

Up to April 1 twenty-eight talkcs were presented before more than 1,300 women and there are many more definitely scheduled before the summer vacation period. It is the intention of the committee to have between 4.000 and 5,000 women hear this message on better lighting in the home. The work is in no way seasonable except for vacation period, and it can be carried on next fall and winter until all the available contacts have been made.

In addition to this program the committee arranged with Mr. Baker to present personally the following list of addresses on better lighting:

Name	City	Attendance
Building Owners Association (twice)	Portland	150
Display Mens Club	Seattle	100
Brigham Young University	Provo	800
University of Utah	Salt Lake	200
Electric Club	Seattle	75
Advertising Club	Seattle	100
Building Owners Association	Seattle	100
Puget Sound Power & Light Company (Sales Dept.)	Seattle	75
		1,550

Summary

It has been observed that the lighting talks to the ladies of the home go a long way in breaking down sales resistance to additional wiring for both lighting and appliance outlets. Contractors report more favorable interviews and more rapid acceptance on the part of people who have heard the lectures. There is also much good resulting from a public relations angle. The people appreciate the endeavor of the industry to assist them in properly using electric service.

The lighting bureau now has on hand sufficient demonstration equipment for any kind of lighting talks. This is available to all the member companies who wish to use it.

A complete copy of the talk, entitled "Vision and Light" is reproduced in the following paragraphs.

Fig. 1. Some of exhibits used with "lighting education" talks.

Vision and Light

IT IS with a great deal of pleasure and satisfaction that we of the lighting profession are now in a position through research and science to give to the world practical data and suggestions for the proper use of artificial light.

We know light to be vibrations or wave lengths, and the knowledge we now have of its effect upon human emotion gives us our inspiration or incentive to study its control and with that control give you, to a greater or less degree, opportunities which would ordinarily be denied you when day is done. In other words, we turn night into day. After taking a moment or two in a discussion of that part of our body which functions with light (the eye) we will again speak of electric light control and its effect.

Remarks Preceding Chart 1.—It may safely be said that the eye is the most marvelous piece of organic machinery in the body and also the most flexible and abuse-resisting organ we possess. In main structural characteristics it is like a camera, although the camera is a more or less fixed device whereas the eye is flexible.

Remarks with Chart 1.—Let us examine this chart which shows the relation of light to sight. A rough sketch of the eye—the stationery lens—the iris—the focusing lens—the retina. Light enters the eye through the stationery lens. The iris opens or closes automatically controlling the amount of light that shall be received. Light then passes through the focusing lens, focusing an image upon the retina.

Remarks Preceding Chart 2.—In considering proper or improper lighting in relation to the eye, there are two main abuses—gloom and glare. Gloom is caused by **too little light.** Glare is caused by **too much light reaching the eye from an improper direction or misplaced light source.**

First, then, let us consider the effect of gloom on the eye. The human eye is adaptable to such a degree that it can differentiate between relative degrees of light, and perceive form. Therefore, the recognition of detail needs varying degrees of light or illumination upon the form subject.

Remarks with Chart 2.—Let us assume to have an object at this point about fourteen or fifteen inches from the eye, which is normal reading distance. Following the lines you will find they pass through the focusing lens and make an image on the retina this size. Again, assuming that there is not enough light at this point to see the object clearly the only other thing to do then is to draw the object closer to the eye, which does not put any more light on the object, but, following the lines again through the eye, we find it focuses an increased image **this** size on the retina.

In doing this we do two things, one dangerous, the other unnatural. The dangerous thing is increasing the accident hazard, since the nearer a person's eyes are to moving objects, the greater the danger of accidents to them.

The unnatural thing is, whenever we bring an object close to our eyes, we have to turn the eyes inward as shown here. With the object out at this point, (lower part of chart No. 2) the line goes through the center focusing lens to the retina. It may clearly be seen as the object is drawn closer how the lens would have to turn inward so as to focus properly, and this demands muscular effort on the part of little delicate eye muscles, that are not made for prolonged exertion, but are made for fine and quick adjustments. This prolonged turning-in taxes the nervous system and produces one of the most common forms of eye strain.

Further, every inch closer to our faces we bring an object, shortens our focus, by changing the thickness of this focusing lens. This also is an act that nature never meant us to maintain for a long period of time, and the drain upon nerve energy from this source produces not merely eye strain, but extreme general bodily fatigue.

Remarks with Chart 3.—We will now turn to the equal, and perhaps more common lighting fault, "glare." This you will remember, we spoke of as too much light reaching the eye from an improper direc-tion, or misplaced light source. The best way to describe glare and its effect is to demonstrate it, (Make demonstrations of glare. Hold a 100-watt bare lamp back of the hole in the card, then switch it on. Call attention to difficulty in reading some of the large

lettering on the face of the card. Small lettering nearly impossible to see.)

Remarks with Chart 4.—You are now supposed to be looking right into the eye. The back of the eye represented by the outer circle is the retina. At this point we have the optic nerve which comes into the back of the eye from the brain. This area represented by the purple dot is known as the "central vision" area while the circle around it represents our "form vision" area or what is known as periferial area. Around this we have what is known as our "color vision" area of which we will speak later.

Now let us see what occurred when we put the glaring light in your eye. We bleached out this purple spot. If I were to hold an object in my hand fourteen inches from the eye and look at it, I will call into use nerves in a small area in the retina of the eye (point to purple dot) which immediately begins to energize or excite until the nerves in that area are turned a purple hue.

While I am looking at this object in my hand I can see objects surrounding it, that is the floor, the walls, people or things within a certain range and these are seen in this area (point to circle surrounding the purple dot) which is known as form vision area. These nerves are excited into a yellow hue. When that glaring light beam entered your eye the iris of the eye closed down as far as it possibly could to shut out the excess light, but did not completely close, and therefore, the ray of light went through the focusing lens and started a bleaching process, attacking the purple first. If it had continued it would have bleached out the yellow as well, which accounts for your inability to see when glaring light rays enter the eye.

While we have this chart before us we may logically discuss color sensation. The area marked here (point out) in color is that area in the retina of the eye which causes the sensation of color, and color as we have said consists of vibrations of various wave lengths. There is such a thing as color differentiation. That is to say, there are eyes which see color more vividly than others, also eyes that see colors differently. In this latter case nature has reversed the wavelength area. Then there are eyes in which everything looks gray, this might be termed color blindness in which the color area does not function at all.

Remarks Preceding Chart 5.—It is said that no two human beings in the world see color exactly alike. We have come to believe fingerprint experts when they tell us that no two finger prints in the world are alike, and the various parts of the eye which go to make up our whole vision are far more complicated than are our finger tips.

Remarks with Chart 5—(Chart-pigment color.) Here are the three primary colors of pigment, together with their secondary colors. You will notice the primaries are red, yellow and blue. Out of these three primary colors we are able to get some 600,000 tints and shades.

Remarks with Chart 6.—This next chart (6) shows the primary and secondary colors of light sensation. The principle of primary and secondary is exactly the same as in pigment. However, the primaries you will notice are different. These primaries are red, purple, and green. Out of these three primaries we get something like 60,000 tones and shades of light sensation.

Remarks Preceding Chart 7.—Let us consider those things that we have just gone over as basic and fundamental, or cause, and suppose that we now consider the closest relation, effect.

Remarks with Chart 7.—What do you suppose causes these boys' eyes to strain as this picture shows? (Show Chart 7.)

Remarks with Chart 8.—The blackboard between the windows is the same as the demonstration of glare we made, which effects the eyes as explained; that is, the purple dot is bleached out.

Another angle presents itself in these pictures which should be of interest to parents as well as to teachers. Note the expression on the teacher's face. She wonders what makes these boys so "dumb." It's the condition of lighting.

We are happy to say that in modern schools this condition is not permitted to exist; the blackboards now are placed properly with relation to the light. Likewise in modern schools the executives and authorities have recognized the value of the right kind and the right amount of light for class study and now demand it. (Briefly explain the function of the enclosing globe over the lamp, how the intensity per unit area of the light source is reduced and the light is softened and diffused for best visual acuity. How the units are spaced for best distribution of light and elimination of shadows. How it takes a given amount of light to fill a given space. Do not mention anything in a commercial way.) Let us hope soon to have all schools modern, not only in lighting but every other way.

Remarks with Charts 9 and 10.—Let us look for a moment as some statistics relating to school lighting: (Read charts)

24,000,000 estimated national school enrollment.

25 per cent or 6,000,000 have defective vision.

67 per cent or 4,020,000 are retarded in study.

$64.15 average educational cost per pupil per year.

257,800,000 ineffectively used each year.

Largely because of: (next chart)

1. Poor control of natural light.
2. Incorrect artificial light.
3. Glare from highly polished surfaces.
4. Home-reading in poor light.
5. Distance at which work is held.
6. Poorly lighted blackboards.
7. Blackboard wrongly placed with respect to lighting.
8. Too much contrast in room.
9. Lack of education in the use of light with respect to the eyes.

Remarks with Charts 11 and 12. These same conditions are carried into the homes, especially with school home-work. Like this for instance (show Chart 11. Explain light reflection, etc.) When the lighting has been corrected, it will result in this (Chart 12.) Note posture, contentment and general appearance of room as compared with this (back to Chart 11.)

There also is another angle to these pictures which should have the interest of the teacher or school executive especially. (Turn back to Chart 11 and call attention to circles under the girl's eyes.) A parent might accuse or attack a teacher or school executive for sending this child home with home-work on the basis that they give them five or six hours' study in the school room and then send them home with another hour or two hours' work which tires them out, and it is reasonable to justify a statement of that kind when you look at this girl's face. However, (turn again to Chart 12.) It is not a condition of the child's health, it is the condition of lighting. (Bring out the point that it does not make any difference in what position the child sits, the conditions are comfortable for reading, writing or study. Explain how proper lighting is obtained. The light should be soft and free from glare, all lamp bulbs should be shaded. Further detail may be given here, but do not mention anything in a commercial way.)

Remarks with Chart 13.—Other conditions in the home also are vitally contingent upon the lighting. Decorations in the home if not properly handled are materially changed and in many cases badly distorted when day is done. First we will give you a demonstration of the effect of colored light falling on colored pigment, and then see what this would mean in a home. (Set up Chart 5 and turn on red light. Call attention to the several changes.) Now let us see what this would mean in a home and assume that (Chart 13) every thing is as they want it in the daytime, but when night comes with no other lighting in the room than the red bridge lamp (turn on red light) here is what you would get.

(Call attention to changes of settee, draperies, and if red and white light is switched alternately, the flowers will disappear from the bowl on the table.)

Conclusion

Conclude your remarks in any way suitable to yourself. However, it is suggested that in conclusion you make an explanation of how this room in chart 13 may still have floor lamps, table lamps, etc., if desired, and retain its harmony and beauty during night hours as well as daylight hours providing the floor lamps are supplemented by general lighting.

MERCHANDISING BUREAU

Domestic Electric Refrigeration*

PROBABLY no other subject has caused as much discussion during the past two or three years as electric refrigeration. Nearly every utility sales department has dealt with this phase of selling, to some extent, during this period. We might say that, on the whole, their experiences have been of such a nature as to form a rather forbidding background for a report of this kind. On the other hand we find a certain few companies who have been very successful in the promotion of refrigeration during the last year and a half.

In the preparation of this report the committee has endeavored to discuss electric refrigeration in the light of past experiences, first from the desirability of the refrigeration load in comparison with the range load and, second, the methods found practicable in the development of the refrigeration load in so far as utility sales organizations are concerned.

Comparison of Refrigeration and Range Loads

In the discussion of the first question, the committee has obtained the views of the chief engineers of five of the operating companies in the Northwest in order that it might base this section of its report on actual figures and views from the operating and engineering departments of the several companies. In obtaining these views four questions were asked.

Question No. 1. What do you consider the approximate ratio of investment in development facilities required for the normal range load at normal diversity and the normal refrigerator load?

Answer. To this question one company answers 6½ to 1, where the customer has light only and a range or refrigerator is to be installed; 7½ to 1, where the customer has a range and a refrigerator is to be installed. Two companies state the ratio to be 4 to 1. Another 8 to 1, and the fifth company answers 50 to 1. The last company mentioned considered the additional load to require no increase in investment until a definite saturation point had been reached, which seemed to it so far distant that additional investment was not an important factor at the present time. In other words, this statement is made without reallocating the unit charges to take in the additional connected load. From these answers we draw the conclusion that the average ratio of investment is approximately six to one. In using this average we take into consideration that this ratio is based on a reallocation of the unit charges to include the added load. On the other hand, it may be considered, and is considered by some companies, a load and revenue without additional investment for some time to come.

Question No. 2. Do you consider the refrigerator as a breeder of trouble to your other customers?

All five companies answered "No" to this question.

Question No. 3. How does the cost of servicing refrigerators compare with the cost of servicing ranges?

To this question we received a variety of answers, depending entirely on the type of machine handled. One company reports the cost of servicing refrigerators at $2 per year and ranges at $5 per year. Two companies reported approximately the same service cost per refrigerator frost tank as per range. Two companies report the cost of servicing refrigerators in the ratio of ten to one, refrigerators costing ten times more than the electric range, based on dollar service cost per range or refrigerator. It might be well to bring up at this time an objection offered by one engineer. He states that refrigerator motors he has tested show a power factor of about 50 per cent which is not a desirable load from an engineering standpoint as the distribution system is burdened with too much reactive component. This is true, but, on the other hand, one 100-hp. squirrel cage or slip ring motor could cause more reactive component to the system than one hundred small refrigerator motors. At the same time, we are ever ready to take on 100-hp. motors in any quantity at a lower rate.

In the final analysis we find that the whole question of the desirability of selling refrigeration, from the central station standpoint, is dependent upon the element of service cost and consequently we find a sharp division of opinion among the five companies reporting, depending entirely on the type of refrigerator handled.

Certain companies report that, after reallocating the investment cost, they have approximately $50 invested for every refrigerator added to the lines. On an average rate of 7 cents, where the customer has only light before refrigeration is installed, our gross revenue would be approximately $39. After deducting our service cost of $2 a year, our gross, exclusive of service cost, would be $37, or about 74 per cent on the investment before operating charges are deducted. Assuming that we have an operating ratio of 60 per cent, exclusive of maintenance on the machine itself, we have $15 left after the operating expenses are deducted for interest and depreciation, amounting to 30 per cent net on the money invested. Where the customer has a range already installed and an average rate of about 2 cents, our gross would be approximately $12 per year. Deducting the $2 service charge the gross would be $10, less 60 per cent operating ratio, net $4 or 8 per cent for interest and depreciation, assuming that we have $50 invested for the refrigerator. As a matter of fact, where the customer has a range already installed, there would be an investment of approximately $40 which would leave 10 per cent for interest and depreciation. On the basis of a 3 cent rate the return would be approximately $18 a year. Deducting the charges as before leaves a little over 12 per cent for interest and depreciation. The actual revenue, of course, is based on the rate covering this class of service.

Question No. 4. Do you consider the value of the refrigeration load sufficient, from an engineering and economic standpoint, to warrant an aggressive and extensive merchandising effort from central station merchandising departments for the purpose of increasing this particular type of business?

Two companies answer "No"; three answer "Yes." We have used the electric range as a standard of comparison, realizing that the electric range is practically the only accepted load to secure which every utility is willing to spend money through its sales organization. We have tried to present this section of our paper from a purely unbiased standpoint and leave you to draw your own conclusions.

Development of the Refrigeration Load from the Selling Standpoint

No one ever learned to swim by merely getting his feet wet. The same can be said of the central station in the promotion of refrigeration. If you do not go into it wholeheartedly you will never receive the full benefits that it offers. Assuming that you realize the benefits and importance of this load, to the central station, we submit the following suggestions in the sale of the electric refrigerator.

Sales Organizations

First, we believe that the sale of electric refrigeration, to be successful, must be highly specialized, and that a full time salesman should be maintained throughout the year in every locality large enough, assuming of course that general salesmen will also sell refrigeration. Since many companies are taking on radios these two activities may be dovetailed in such a way as to support a year round salesman, especially since the peak selling seasons do not conflict. We further recommend the same shock troop methods as are used on other appliances throughout certain seasons of the year, such as campaigns during the spring and summer months, employing as many sales people as possible.

Sales Policies

We believe that education is the chief and paramount objective in the sale of the electric refrigerator. If educational advertising and demonstration stunts are

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* Report of domestic electric refrigeration committee—**Glenn L. Jackson,** Mountain States Power Company, chairman. **The California Oregon Power Company:** J. J. Buchter. **Grays Harbor Railway & Light Company:** H. G. Kelsey. **Walker & Pratt Manufacturing Company:** J. L. White (formerly Portland Electric Power Company).

not carried on throughout the entire year then it is highly important that the educational program be started shortly after January 1, in order to pave the way for intensive spring and summer selling campaigns. We feel that success in selling will be in direct proportion to the effectiveness of your educational program. Your educational program can best be put across by the personal contact of well trained salesmen.

As to the features of the sales policies, we do not favor trade-ins on ice boxes but suggest that help be extended in disposing of these boxes for the customer. We have found, in the past, that classified advertising featuring used ice boxes results in the disposal of a considerable portion of them.

We recommend trial periods for interested and responsible parties who can and may buy. Any appliance that can be demonstrated at a legitimate expense should be demonstrated whenever possible.

We recommend that the utility advertise definite trade names of refrigerators instead of advertising refrigeration in general. Experiences of most companies lead us to believe that advertising of definite names will bring better results to the field of refrigeration as a whole than general advertising.

We further recommend close co-operation with competitive dealers, for it must be remembered that the electric refrigerator is still in a more or less pioneer stage and that it would be detrimental to the industry to arouse confusion and doubt in the minds of the customer through highly competitive methods, as between different types of refrigerators.

Time Payments

The most important problem discussed by the committee in the promotion of sales is the matter of time payments. We must consider for the present, at least, that the potential market is composed largely of electric range users, and that the business is therefore not competitive within itself. We are in competition with the piano, automobile, phonograph, radio, furniture, oil furnace, and with any other item that plays on the consumer's marginal dollar. Time payments on articles such as pianos, furniture, oil furnaces, radios, and so on run as high as 40 months, with an interest rate at approximately 8 per cent. In competition with luxuries such as these, we must have a strong pull from the standpoint of ease of ownership because of the luxurious nature of the competitive articles mentioned.

Again, we must face the problem of the ever decreasing number of appliance sales in a given price field, and we must be in a position to lower our monthly payments to a point where they will fit into a greater number of home owners' budgets before we can hope to sell refrigeration in volume. We, of the utility, should be more ready to extend time payments on contracts than our competitors, due to the fact that the central station receives the benefit of the load. We have this question to decide. Shall we sell refrigeration at a relatively high price with short time payments, in comparison with competition and wait until the price of refrigerators declines to a figure that will appeal to the average home owner, or shall we place the merchandise on easy terms and receive the load and revenue at once? In our decision we must consider the value of the load we would receive in the meantime. We believe the latter to be the best from the central station viewpoint, for the following reasons:

1. We already have credit organizations built up in our several companies that check credits closely and are capable of following up contract accounts without excessive loss.

2. Today's model refrigerator can be sold with the assurance of a minimum of service and depreciation.

3. We receive a legitimate interest charge on the money invested.

4. We can protect ourselves by insuring refrigerators sold on time payment contracts.

5. We are in a position to watch carefully the condition of the refrigerator due to our system of working the user, which can be made to cover the following: (a) investigation to ascertain the care being taken of the refrigerator. (b) adjusting complaints, and, (c) picking up prospects for refrigerator sales.

It is possible for us, then, to extend our time payment contracts covering electric refrigerators to 24 or 36 months, without additional overhead or additional loss from contract sales.

In conclusion, the committee feels that the sale of refrigeration can be made profitable both from the merchandising and operating standpoint by the above methods and with the developments of the electric refrigerator in the future, that many of the objections at present, will be solved to the satisfaction of all concerned.

Electric Range Merchandising Policies*

THERE has been very little change in the marketing of ranges. The committee has tried to bring out a few things that will not be merely a review of previous range problems.

A questionnaire was made up and presented to each committeeman, and from the replies we shall try to select the policies which we believe are adaptable for the majority of members.

Trade-Ins

The first question was relative to the best way to handle trade-ins.

The Mountain States Power Company's report on trade-ins is interesting. For the past two years it has taken wood, coal and gas ranges up to 10 per cent of the value of the new range. If the customer does not think this is allowance enough, it offers the used range for sale at the price the customer requests. It reports that this plan has worked very satisfactorily, and that profit has actually been made on trade-ins.

In Portland, the trade-in experiment has been rather expensive. A large number of used ranges were placed in stock, and being unsalable, were scrapped.

In eastern Oregon, the trade-ins are taken in at a low value, making it possible to dispose of them easily.

In Spokane, some uninterested company in another location (financed by the power company) appraises and sells used ranges. They report they are more than pleased with the plan and have made a small amount of money above the expense of handling.

This condition has its serious side, because department and furniture stores are taking in used ranges, both gas and coal, at prices higher than we can afford. There are two reasons for their doing this; first, because their margin is greater on non-electric ranges; second because they have facilities to recondition and sell these used ranges at a profit.

We have found that trade-ins are more easily disposed of in the smaller communities.

Terms of Payment

The second question was relative to the down-payment plan.

Except for campaign periods, it has been the policy of most members to require a down-payment of 10 per cent with balance to be paid in eighteen months. Unless the price of electric ranges is reduced, it is rapidly becoming necessary to extend these terms, so as to be able to compete with fuel ranges. Members have all agreed that the question of credit cannot be viewed from the down-payment angle, or even from the standpoint of the length of contract, so long as the credit conditions are thoroughly and intelligently investigated.

We have found that it is not the total range price so much as the ease with which the range may be procured that attracts our prospective range customers. Because of a low down-payment and a fairly low monthly payment, the customer is willing to pay a high rate of interest or carrying charge.

To cite an outstanding example of this preference, perhaps recall the campaign put on by the Georgia Power Company with General Electric refrigerators. During this campaign last summer, it allowed their contracts to run for three years, adding 20 per cent to the cash price as a carrying charge.

We believe the amount of time covered by the contract should depend largely on the article itself; ranges and refrigerators, for example, having a small rate of depreciation, can be sold on much longer terms.

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* Report of domestic electric range committee—**G. A. Kumler,** Portland Electric Power Company, chairman. **Eastern Oregon Light & Power Company:** J. P. Lottridge. **Mountain States Power Company:** Glenn L. Jackson. **Northwestern Electric Company:** J. B. Buman. **Puget Sound Power & Light Company:** R. W. Clark.

Premiums and Price Cutting

The third question asked was concerning premiums. The policy of giving premiums is just another method of cutting price. When power companies once begin this practice, they find that it proves antagonistic to outside dealers to such an extent that it causes friction everywhere. The dealers, in order to out-do the power companies, will offer larger and better premiums, with the result that neither the dealer nor the power company make a profit. This condition is inevitable and causes the dealers to push non-electric and cheaper ranges in order to compete with the power companies. The entire committee has agreed that it is poor policy to give premiums.

Wiring

The fourth question was regarding wiring.

One of the greatest points of resistance in the sale of electric ranges is the wiring. This problem is an important one, worthy of much consideration. In the Northwest, the fixed price is $35 per range. Some of our members believe the state code to be too severe and the cost of wiring entirely too high. We have found that many of our prospective range customers, especially in the smaller communities, live in old houses, with knob and tube wiring, and they cannot understand why the range cannot be wired in by the same method; in other words, why range wiring would prove any more dangerous than the wiring already installed in the house.

Equipment in Public Institutions

Next comes range equipment in public institutions. We recognize this also as a problem of paramount importance. We have agreed that all public institutions, including churches, should have up-to-the-minute installations of modern equipment. It should be inspected at least twice each year, and when found to be obsolete, should be replaced by new equipment, the expense to be divided equally between the power company serving the building and the range manufacturer. Strictly modern equipment is necessary because the younger generation using this equipment will inevitably be prospects for electric ranges and other appliances in the near future.

Co-operation with Dealers

We believe that co-operation with dealers is absolutely essential to the success of our program. Ways of realizing this co-operation vary. The members who have been subsidizing, or trying to work with electrical contractor-dealers, are meeting with a minimum amount of success. This is perhaps partly due to the fact that in most instances the contractor-dealer is a very poor merchandiser and in the end must leave the burden to be carried by the power company.

In Portland, however, the power companies have been quite successful in co-operating with dealers, referring, however, to stove merchants rather than to electrical contractor-dealers. More than a year ago, the Portland power companies gave a dinner, inviting as guests all heads of electrical departments of all department and furniture stores, and four of the leading electrical dealers were also invited. It was surprising to find that men associated in the same line of endeavor for so many years had never even so much as met each other, either in a business or social way. This effort to bring them together, on the part of the power companies, led to the formation of an association which now meets once each month. This association has accomplished a great deal, and is expected to operate on a much larger scale during 1929.

Sales and Campaign Plans for the Future

In most towns that are not building rapidly, we find it necessary to give a great deal more attention to old houses, in order to add to our list of prospective range users. In other words, we have taken the "cream" and it is now our job to go out after some of the harder business.

Many heads of the family, who are entirely "sold" on the electric range, are low wage earners, and since it is quite impossible to raise their wages, we must face the problem of cutting down their payments to the minimum amount.

In Portland, through the association, it was agreed to add a carrying charge of ½ of 1 per cent per month on unpaid balances. We find that this plan has not caused the loss of any business, and it surely is a step toward giving the low wage earner longer term contracts.

The committee has found that conducting two range campaigns per year, where special inducements are offered, has had a tendency to slow down the sale of ranges during the remainder of the year. It finds that prospective customers will wait for the campaigns—the premiums—the bargains. Electric ranges should be sold during the twelve months of the year.

We believe the only successful way to market ranges is by "man power." These men should be intelligently and sufficiently trained to sell electric cookery. To accomplish all this means many sales meetings and endless persistence. Each salesman must have a well-grounded foundation knowledge of electric cookery to enable him to meet all competition with the surety that "the electric way" leads the field, and the well-trained salesman of electric ranges can far outsell the best of competitors.

Electric Water Heating*

THE committee sent out a questionnaire to each of the member companies of the Northwest division and these questions together with the summarized answers from fifteen companies as well as some comments from the committee go to make up the following report.

The conclusions of the committee are reflected pretty generally throughout the entire report. This being the first report of the Water Heating Committee, the committee did not wish to form too many conclusions but rather to present the experience of the member companies.

At the prevailing rates for flat rate water heating, it is possible by correct installation, accurately rated water heaters, efficient tank covers, and thermostatic control to make the rate for this service two-thirds of a cent per kw.-hr. Flat rate water heating is returning $3.50 to $5 a month per kw. connected. This point is brought out for comparison with the return on industrial applications of $2 per month per kw. connected.

One company reporting has been selling water heating on a metered basis only and has been installing a water heater combination whereby one heater permits the heating and storage of approximately one-third of the tank for ordinary use, with the second heater placed near the bottom of the tank to take care of the larger demand for hot water. This company is satisfied that this set-up comes nearer meeting the general demand for ideal installation than any other method experienced, and this installation is recommended by the committee for companies selling hot water heating on a metered basis.

Efficiency of installation should be borne in mind by all companies. Effort should be made by companies selling flat rate heaters to educate the building contractors, architects and plumbers to the use of 40-gal. tanks as standard tank installation.

Tests for National Committee

We have had requests from the National Water Heating Committee to consider making a water heating survey in the Northwest. M. T. Crawford, a member of this committee is also a member of the national committee and recommends that since the work is of national importance the N.E.L.A. purchase the instruments and finance the tests, and further that this committee go on record as favoring such plan. In order to get information in regard to the shape of load curve, time of peak, diversity factor, etc, totalizing meters should be installed to get coincident records of the operation of a total of at least sixty or seventy-five units. Where there are several heaters located fairly close together they can be handled by one printometer and pressure wires to distant dial totalizing installations at each heater. The majority of the installations, however, will require a separate printometer for each. A certain number of these can be handled by installing an ordinary Bristol voltmeter on the heater circuit

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* Report of water heating committee—**J. W. Wisdom, Jr.**, Northwestern Electric Company, chairman. **A. & F. Sales Corporation:** Millard Sebern. **Idaho Power Company:** J. B. McLain. **Portland Electric Power Company:** H. A. Joslyn. **Puget Sound Power & Light Company:** M. T. Crawford. **The Washington Water Power Company:** R. B. McElroy.

to show the time it is switched on and switched off, from which a load curve can be plotted. Mr. Crawford's company has about a dozen curve drawing voltmeters that could be borrowed for this work and the N.E.L.A.'s present metering equipment, consisting of fifteen printometers with ten dial attachments for each, can be used to totalize about thirty or thirty-five heaters . The committee estimates that at least twenty additional printometers should be purchased in order to get enough equipment to complete a test that would really be informative. These additional printometers need not be fitted with the distant dial equipment, so that the cost would not exceed $150 each.

With this program in mind a series of tests could be made, getting next summer, fall and winter conditions ready for a report about a year hence at the following costs:

20 Printometers	$3,000
Installing control circuits, distant dials and metering equipment, labor and material	1,500
Transportation and incidentals	500
Total approximate estimate	$5,000

The national association should be willing to appropriate $15,000 to permit tests to be made in at least three different localities and the manufacturers might be willing to contribute toward this work.

The water heating business is looked on by many executives as a very doubtful source of profit, just as the electric range originally was, and there is no way of arriving at a definite conclusion as to the proper rate, type of equipment, method of installation, and condition of operation which gives both customer satisfaction and company profit without making a complete survey.

Additional Experience Record Necessary

It is the committee's recommendation that companies designate some individual in each organization to be directly in charge of water heating.

This committee recommends that next year's committee be appointed earlier so that it can begin its work at an earlier date, thus giving the reporting companies a better opportunity to keep the records that may be useful to the committee in forming a report. In explanation—the companies might take this year's questions as a guide for a recording desirable information, whereas next year's committee might present an entirely different set of questions on which very little information would be available.

Tabulation of Answers to Questions

The detailed report of questions and answers follows:

1. How many water heaters do you have on your system on flat rate service?

   Total number of flat rate heaters reported..18,662

2. How many water heaters do you have on your system on flat rate service?

   Total number metered heaters reported....4,042

3. What is the average size of flat rate heaters?

   Wattage of flat rate heaters nearly all 738 to 850 watts average.

4. What is the average size of metered water heaters?

   Sixteen per cent metered heaters, 3,500-watts capacity.

   Five per cent metered heaters, 3,000-watts capacity.

   Seventy-eight per cent metered heaters, 1,000-watts capacity.

   One per cent metered heaters other wattages.

   It will be noted that 78 per cent of the heaters reported are of 1,000-watt capacity. This would lead to the conclusion that 1,000-watt heaters are sufficient to take care of the majority of water heating customers. It is true, however, that installations are not limited to one heater each.

5. What is the average monthly kw.-hr. consumption of flat rate water heaters?

   Average monthly kw-hr. consumption of flat rate heaters was 468. A survey of 28 flat rate water heater installations in the city of Portland showed the heaters used only 75 per cent of their possible consumption, the conclusion being that the following conditions were responsible:

   (a) Accurately rated water heaters
   (b) Efficient tank covers
   (c) Correct installation
   (d) Thermostatic control
   (e) Alternate switching
   (f) Booster heaters

   Just what portion of the saving in current is chargeable to any one of the above six conditions it is not possible to estimate accurately. The average return per kw.-hr. on the above 28 heaters was approximately ⅔ cent.

6. What is the average monthly kw.-hr. consumption of metered water heaters?

   Average monthly kw.-hr. consumption of metered heaters from reporting companies having accurate data was 252. A good many of the reporting companies have recently established metered rates of 1½ cents. This would give a return of approximately $3.78 per month.

7. Does your company sell flat rate water heaters to other than range users?

   Five companies sell flat rate water heating service to range users only.

   Six companies sell flat rate water heating service to any customer.

   Four companies do not sell flat rate service.

8. What are your rates for flat rate water heaters when used in connection with ranges?

   Rates for flat rate water heating when used in connection with range are for 89 per cent of water heaters reported $3.25 to $3.50 per kw. month; for 9 per cent, $4 to $5.50 per kw. month; 1 per cent scattered.

9. What rates for flat rate water heaters to other than range customers?

   Rates for flat rate water heating to other than range users are $4 to $5.50 per kw. month.

10. What is average monthly revenue from flat rate water heaters?

    Monthly revenue from flat rate water heaters ranges from $2.40 to $3.04 per heater.

11. What is your average monthly revenue from metered water heaters?

    Monthly revenue from metered water heating service ranges from $3.75 to $4.89 per heater. The company reporting 78 per cent of metered water heaters showed a monthly revenue of $4 per heater.

12. What is your rate for metered water heater service?

    The rate for current on 78 per cent of the metered water heaters reported is 1½ cent per kw-hr. with a $2 monthly minimum charge per kw. connected. The rate for current on 16 per cent of the metered water heaters reported is a combination rate which would make the rate for water heating between 1 and 1½ cent. Other metered water heaters were on various rates from 3 to 1 cent per kw.-hr.

13. Are your flat rate water heaters switched against part of the range?

    Ninety per cent of flat rate heaters are switched against part of the range. Ten per cent of flat rate heaters are not switched against part of the range.

14. If so, what part?

    When switched against part of the range, some are switched against the oven and some against the cooking top.

15. If your flat rate water heaters are switched against part of the range, do they raise your system peak?

When switched against part of the range three companies report it raises their system peak; three companies report it does not raise their system peak.

16. If so, what percentage of your average size water heater?

Sixty-three per cent of water heaters reported advise that when water heaters are switched against part of the range it raises their peak 50 to 54 per cent of the water heater demand, or 50-54 per cent of water heater demand is superimposed on system peak. (Note: tests made in 1925-26 report approximately the same percentage.)

17. If your flat rate water heaters are not switched against part of the range do they raise your system peak?

18. If so, what percentage of your average size water heater?

All companies advise that when flat rate heaters are not switched against part of the range the system peak is raised 100 per cent of the water heater demand. The conclusion is that it is advisable to switch flat rate water heaters against the range.

19. Are your high wattage heaters switched against the range?

Two companies report high wattage heaters switched against part of the range. Two companies report high wattage heaters not switched against part of range.

20. If switched against the range do they raise your system peak?

21. If so, what percentage of your average size water heater?

When switched against part of the range high wattage heaters do not raise the system peak.

22. If your high wattage heaters are not switched against the range do they raise your system peak?

23. If so, what percentage of your average size water heater?

One company reports that when high wattage heaters are not switched against part of the range they raise the system peak 100 per cent of the water heater demand. One company reports that when high wattage heaters are not switched against part of the range they raise the system peak but have no data as to the amount.

24. When flat rate heaters are sold in connection with the ranges do you find it necessary to have greater distribution capacity than when the range only is used?

25. If so, how much?

Eighty-one per cent of water heaters reported advise that when flat rate water heater service is sold with the range no greater distribution capacity is required than if the range only is sold. Nineteen per cent of water heaters reported advise that when flat rate water heater service is sold in connection with the range additional distribution capacity to the amount of 50 per cent of the water heater demand is required.

26. Does your company insist that all tanks be covered when flat rate service is furnished?

Four reporting companies insist that tanks be covered when flat rate service is supplied. One company recommends tank covering, but does not insist. One company advises that future tariffs will require tank covering. The committee deems it very poor practice to permit heaters to be installed on uncovered tanks.

27. If so, what thickness of covering?

Seventy-one per cent of water heaters reported insist on tank covering, 2¼ to 3 in. thick. Nineteen per cent of water heaters reported insist on covering approved by company. Efficiency, not thickness, should govern. Ten per cent of water heaters reported recommend 1 in. covering or equivalent.

28. Does company insist that flat rate heaters be thermostatically controlled?

Thermostatic control of flat rate heaters is not insisted upon. One company advises they favor the practice and will require thermostats in future tariffs.

29. What percentage of kw.-hr. do thermostats save when sold with flat rate heaters?

One company reports a saving of 30 per cent in kw.-hr. consumption on flat rate heaters when thermostats were used. This test was on eight installations. By insisting on proper tank covering combined with thermostats, a saving of approximately 25 per cent of current is effected on flat rate installations as shown by answer to question 5.

30. Does your company insist that flat rate heaters be accurately rated?

Five companies insist that flat rate heaters be accurately rated. One company has used name plate reading but believes more accurate method should be used.

31. How much variation do you permit?

Forty-four per cent of water heaters reported allow 2 per cent variation in wattage from name plate reading. Thirty-seven per cent of water heaters reported allow 5 per cent variation. Nineteen per cent of water heaters reported believe some means should be adopted to secure greater accuracy in the future. The problem of companies selling flat rate heaters is that on new installations, all heaters should be checked and charged on basis of actual demand rather than using name plate rating. This could hardly be made retroactive on heaters in service and about the only solution seems to be that the power companies protect themselves in the future. The jobbers of the heaters should be asked to standardize all heaters sold with the voltage of the lines of the local power company.

32. Does your company push the sale of booster heaters in connection with flat rate heaters?

Three companies report sales effort on metered booster heaters in connection with flat rate service. Seven companies report no efforts along this line. Five companies do not sell flat rate. The committee recommends for companies selling flat rate heaters that sales efforts be made on booster heaters both with the idea of increasing the power company's revenue at a higher rate, and increasing service to the customer.

33. What type (insert, circulation or clamp-on) booster heater do you sell in connection with flat rate heaters?

One company uses clamp-on heaters. One company uses circulation booster heaters. One company uses all types of booster heaters, and is trying to confine to clamp-on. One company sells all types, but usually clamp-on.

34. Are booster heaters thermostatically controlled?

Three companies use thermostatic control with booster heaters. One company does not.

35. If insert or clamp-on booster heaters are used, what place on the tank are they applied?

One company places clamp-on booster heater one foot from top of tank. Two companies place insert or clamp-on booster heaters near the top of the tank.

36. What size booster heater do you recommend for the average installation?

    Three companies use 1,000-watt to 1,500-watt booster heaters. One company uses 3,500-watt booster heaters.

37. Does your company limit the size of flat rate heaters?

    Four companies do not limit the size of flat rate heaters. One company limits them to 1,500-watt capacity. One company limits them to the capacity of the range.

38. Does your company advise architects and builders to wire for water heater as well as range service in new construction?

    Ten answered affirmatively, four negatively, and one did not answer.

Merchandising Organization Problems*

THE GENERAL merchandising committee, after considering to some extent the general merchandise situation, chose to make a study of, and report on, some problems of organization. Although this is a rather general subject and one which must necessarily be influenced by local conditions, it has some phases common to all companies. In order to confine the work of the committee to definite problems, the following questions were set up for investigation and consideration:

1. Number of sales representatives per 1,000 customers that can be profitably engaged in sales work.
2. Type of salesmen to be used, either specialty men, or general representatives, including promotion of sales program by all employees.
3. Amount and type of supervision necessary, for maximum results including prospect filing systems.
4. Best sources for securing a supply of reliable sales representatives.

Size of Organization

The present high percentage of saturation of at least the larger load-building appliances, diminished number of possible new customers and general reductions of rates, indicates that more intensive work is necessary to secure results in the future comparable with the past. It is recommended that sales efforts be as intensive as good business will permit, having in mind that the resulting kw-hr. sales will date from the sale of the load-building merchandise and that the sale of kw.-hr. is the ultimate reason for merchandise sales. With this situation in mind it is recommended by the committee that the possible saturation of major appliances and the sales necessary to attain it be estimated and the sales efforts be adjusted accordingly, rather than setting quotas figured on the possible attainments of the existing sales organization.

Replies to questionnaires sent out to member companies were incomplete and the number of sales representatives per 1,000 customers were not stated definitely, making it impossible to tabulate the report. However, the sales per customer were directly in proportion to the sales efforts, or number of representatives per 1,000 customers which varied from 1 to 4,000 down to 1 to 500. As stated above the number of sales representatives to be profitably engaged per 1,000 customers depends on, and must vary with, local conditions, for which reason this committee has not felt justified in recommending any set ratio of sales representatives to customers, but does recommend that the sales crew should be kept as large as is consistent with good business and that maximum consideration be given to the kw-hr. revenue to be derived from the sale of merchandise as well as the merchandise profit.

Type of Salesmen

Replies to questionnaires indicated a unified opinion as to the type of sales representatives to be employed, all being agreed that specialty men secure best results in city territory and are necessary for the pioneering of new merchandise, while general representatives are best for smaller towns and rural territory.

Replies to questionnaires from some of the member companies also indicated that little or no consideration is given to the education and encouragement of all employees to support and take an active part in sales activities. No information was available as to the proportion of the total merchandise sales made by employees not regularly on the sales crew. It is recommended by the committee that every effort be made to encourage all employees to sell merchandise, interest themselves in and support the sales program, they often being in a better position than a sales representative to talk a sale to the customer. It is felt that all employees should be invited to attend sales meetings whenever possible and encouraged by being given credit for sales made and prospects reported. Results of such encouragement to, and participation by, all employees in the sale of merchandise will not only be reflected in the volume of sales both of merchandise and kw.-hr., but will be conducive to good customer relations. An employee with a desire to make a sale is bound to have a good attitude toward customers at all times.

Supervision

It is found in general that in locations sufficiently large to maintain a sales organization, regular supervision is maintained, and the committee wishes only to point out the importance of such supervisory positions, and that they should be held by men of the right caliber. The maximum volumme of sales is a result of enthusiasm and knowledge of the merchandise, both of which must be supplied to the sales organization by the man directly in charge, which calls for initiative and new thinking on his part. Criticisms of men in such positions are more apt to be for sins of omission than for sins of commission.

In small towns or rural territories it was found that the sales supervision in many cases falls to either a district or division manager, who has many other duties to perform, the number of which is apt to be a deciding factor in the amount of consideration given to the activities of sales representatives and the encouragement of all employees to sell. District and division managers cannot be urged too strongly to give, in spite of other responsibilities, their best thought and encouragement to sales activities, this being the greatest source of increasing kw.-hr. revenue.

Prospect Files

Consideration was given to prospect filing systems, as it was considered by the committee that proper accounting of prospects is essentially a part of sales supervision and something that cannot be left to the sales representative to plan and carry on for himself, but which is very necessary if efficient and maximum results are to be secured. Reports from member companies indicate that prospect filing systems vary from very complete files to none at all. A prospect record is an account of potential business, and is just as important, if not more so, than accounting of business already connected to the distribution system. It is impossible to give in this report a detailed description, or samples of systems in use, but it is recommended and urged that where not now in use, a workable system be installed, and that it be recommended and encouraged by the management which will insure its completeness and continued use.

Source of Salemen

Replies to questionnaires as to the best source of supply of sales representatives were unanimous in stating that sales crew personnel should be recruited from other departments of the company organization. In view of this agreement, it is desired to point out the necessity of encouraging all employees to support and take part in the sales work, which will increase the sales and develop material for the sales organization at a future time.

Recommendations

After careful consideration of the questions stated in the beginning, the general merchandising committee wishes to recommend:

First: That quotas be set in proportion to the pos-

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* Report of general merchandising committee—L. W. Brainard, Idaho Power Company, chairman. Northwestern Electric Company: J. B. Buman. Pacific Power & Light Company: H. W. Cooper. Utah Power & Light Company: A. W. Huckins. Walker & Pratt Manufacturing Company: J. L. White (formerly Portland Electric Power Company).

sibilities of the territory served and sales organizations be built up to the estimated accomplishments rather than setting quotas in proportion to the existing sales crew.

Second: That all employees be encouraged in sales work, both for the assistance they will be in securing results and as training for future sales crew personnel.

Third: That those holding supervisory positions in sales work be impressed with their obligations, particularly where such supervision is the responsibility of district and division managers, having other duties to perform, and that in either case an important part of sales supervision, in view of increasing saturation, decreasing rates and decreasing possibilities for growth, is a workable and up-to-date record of prospects.

The following article by V. H. Moon of the Pacific Power & Light Company outlining his company's merchandising plan for 1929 is presented as representing an excellent example of definite merchandise planning.

Planning Ahead in Merchandise Sales

By V. H. MOON*

IT MUST be apparent to everyone interested that it is necessary to plan ahead in the sale of electric merchandise. We plan ahead in all activities whether they are those undertaken by companies or by individuals; even the simplest journey is planned in advance. But in even the simplest activities there are certain questions that must be answered before the journey can be undertaken intelligently.

1. Where are we going?
2. Do we want to get there?
3. How are we going to get there?

In the rather complex activity of selling a large quantity of electrical merchandise it is equally necessary that we ask ourselves the same three questions, which would be:

1. How much merchandise do we want to sell?
2. Do we (meaning the officials of the company) wish to get there?
3. How are we going to sell this quantity of merchandise?

In submitting the plan which follows it is believed that these three fundamental questions have been recognized and answered.

First, the plan sets up a definite goal to reach of a million dollars in the year 1929;

Second, the highest officials of the company, beginning with the president, have issued statements in the plan book, which they have personally signed, which leaves no doubt of their desire that the goal be reached;

Third, the entire year's operation, for the attainment of that quota, has been workel out in advance and the responsibility of each individual district determined.

It is realized that this plan is not new, nor is it anything revolutionary. It is believed, however, that it does represent one method of planned merchandise operations which incorporates certain fundamental principles.

A description of the merchandise quota books, and their use, follows:

Page 1 is the title page and indicates that the book contains the 1929 merchandise quota of "That Million" for L..... district. (Fig. 1.)

Page 2 is a message from the merchandise manager to the field men, stating the goal to be reached, commending them for previous jobs well done, and enlisting their enthusiasm for the new year's work. (Fig. 2.)

Page 3 contains personally signed messages from four highest operating executives, namely, the president, the vice-president and general manager, and the two assistant general managers. (Fig. 3.)

Page 4 (Fig. 4) shows pictorially the year's sales program by months. It is desirable that all sales activities be animated. If the sales competition can be made into a game, or a race, it is usually more interesting to

* Presented as part of the report of the general merchandising committee.

1929

Merchandise Quotas

of

THAT MILLION

for

LEWISTON

District

Pacific Power & Light Company

Always at your service

Fig. 1. Sheet No. 1 of Quota Book.

the contestants. The entire year's plan, which is built around the qouta book, has been worked into a "Round the World" tour, in which the contestants (districts) travel by different methods during each monthly campaign. The sketches of the ships, etc., inserted in the calendar column on the left of the page indicate the method of travel. Each district is furnished with a

WE ARE planning to sell One Million Dollars in electric merchandise on Pacific Power & Light Company system this year. We have attempted to assign to each district a part of "THAT MILLION" which will be a just division of the total quota and which will penalize no one for previous jobs well done.

In the past year our Company has made some records in the sale of electric merchandise that have gained national recognition. If we reach our quota of One Million Dollars this year we will attain a mark never before reached by any northwest public utility.

Let's get off to a good start.

Merchandise Manager

Fig. 2. Sheet No. 2 of Quota Book.

THE Directors and Officers of your Company are greatly interested in the successful termination of the sales plans as outlined for this year.

I know you will do the job well for you have the reputation of doing things well. Therefore, I take this means of letting you know that I am with you in every way all along the line. The greater the effort the greater the results.

President

PACIFIC Power & Light Company does not serve a territory that provides a large market for industrial uses of electricity. It is therefore essential that we make every effort to develop as much business as we can through household uses. One might say this is practically the backbone of our business. The building of new revenues through the sale of electric merchandise is a major part of every district manager's duties. I have gone over the merchandise plans for 1929 and I recommend to every manager that he give this plan his unqualified support.

Vice-President and General Manager

IT is gratifying to note that during the last six years the average residential use of electricity on this system has tripled. Undoubtedly aggressive merchandising methods have played a part in this increase. While we are at all times interested in properly serving our communities by building extensions where the revenue will warrant the expenditure, the most attractive new business possible for us to obtain in the residential field is from the sale of additional energy to present users.

Assistant General Manager

THE sale of electric merchandise in large quantities increases the average home owner's use of electricity and consequently increases the Company's revenues. The increased use of electricity in such service is one of the most effective influences toward the ultimate reduction of rates.

Assistant General Manager

Fig. 3. Sheet No. 3 of Quota Book.

THAT MILLION
is composed of the following

Appliance	Showing Comparative Volume and Per Cent. of Total	No. of Pieces	Average Price	Amount
REFRIGERATORS	24%	800	$300.00	$ 340,000 00
RANGES	22.5%	1,500	150.00	225,000.00
WASHERS	22.5%	1,800	125 00	225,000 00
RADIOS	7.5%	500	150 00	75,000.00
IRONERS 500 No. 10; 500 No. 0	6.725%	1,000	67 25	67,250.00
VACUUM CLEANERS	3.75%	750	50.00	37,500 00
WATER HEATERS	2 5%	1,250	20.00	25,000.00
MAZDA LAMPS	2 5%	100,000	25	25,000.00
TELECHRONS	2%	500	40 00	20,000.00
WAFFLE IRONS	1 8%	1,800	10 00	18,000 00
PERCOLATORS	1 1%	1,100	10 00	11,000.00
COOKERS	1 05%	750	14 00	10,500 00
FLAT IRONS	1 025%	2,050	5 00	10,250 00
TOASTERS	55%	1,100	5 00	5,500.00
SPACE HEATERS	5%	1,000	5 00	5,000.00
	TOTAL			$1,000,000 00

Fig. 5. Sheet No. 5 of Quota Book.

6-in. globe on a stand, which is kept on the district manager's desk. This globe has the route marked upon it which the districts are supposed to travel in their "Round the World" race. A map of the particular area being traveled is made up for each campaign. Such maps are furnished all districts.

Buttons are furnished and when the map is mounted on beaver board the buttons are stuck upright along the route of travel, indicating the standings of the districts.

Bulletins, tying-in with the mode of travel, are sent at frequent intervals, giving districts the new positions of the contestants, and keeping them posted at all times.

Fig. 4. Sheet No. 4 of Quota Book.

How THAT MILLION divides by appliances by months

APPLIANCE	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
REFRIGERATORS	20	24	54	182	82	182	80	57	36	21	20	37	800
RANGES	15	53	33	48	370	150	370	150	48	32	33	320	1,500
WASHERS	36	354	207	54	56	37	38	38	443	364	41	74	1,800
RADIOS	100	30	15	10	5	5	5	5	25	75	125	100	500
IRONERS	15	150	150	25	25	25	20	20	250	250	20	50	1,000
VACUUM CLEANERS	16	11	300	329	40	40	26	17	11	16	11	33	750
WATER HEATERS	10	20	20	40	310	194	316	132	40	26	30	185	1,250
MAZDA LAMPS	7,000	6,000	6,000	6,000	4,000	4,000	4,000	6,000	14,000	14,000	15,002	11,002	100,000
TELECHRONS	77	16	10	34	10	30		1	126	21	23	153	500
WAFFLE IRONS	36	500	113	37	28	26	33	26	37	503	118	111	1,800
PERCOLATORS	27	23	18	469	107	26	23	19	23	23	23	167	1,100
COOKERS			2	15	40	380	221	64	4			14	750
FLAT IRONS	60	83	181	130	386	300	167	410	167	82	64	302	2,050
TOASTERS	18	20	370	118	48	48	51	51	51	33	33	221	1,100
SPACE HEATERS	83	61	28						27	90	450	302	1,000

Fig. 6. Sheet No. 6 of Quota Book.

How THAT MILLION divides by volume by appliances by months

APPLIANCE	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT.	NOV.	DEC.	TOTALS
REFRIGERATORS	$ 6,000.00	$ 7,200.00	$16,200.00	$54,900.00	$ 25,500.00	$54,900.00	$24,000 00	$17,100 00	$10,800.00	$ 6,300 00	$ 6,000.00	$11,100 00	$ 240,000
RANGES	2,250.00	4,950 00	4,800.00	7,200.00	55,500.00	22,500.00	55,500 00	22,500 00	7,200 00	4,800.00	4,800.00	33,000 00	225,000
WASHERS	4,500 00	44,250 00	33,375.00	6,750 00	7,000 00	4,625 00	4,750 00	4,500 00	55,375 00	45,500 00	5,125 00	9,250 00	225,000
RADIOS	15,000 00	4,500.00	2,250.00	1,500.00	750.00	750.00	750.00	750.00	3,750.00	11,250 00	18,750 00	15,000 00	75,000
IRONERS	1,008.75	10,087 50	10,087.50	1,681.25	1,681.25	1,681.25	1,345 00	1,345.00	16,812 50	16,812 50	1,345 00	3,362 50	67,250
VACUUM CLEANERS	800 00	550 00	15,000 00	11,450.00	2,000.00	2,000.00	1,300 00	850.00	550 00	800 00	550 00	1,650 00	37,500
WATER HEATERS	200 00	520 00	400 00	800 00	6,200 00	2,480 00	6,320.00	2,460 00	800 00	520 00	600 00	3,700 00	25,000
MAZDA LAMPS	1,750 50	1,500 00	1,500.00	1,500 00	1,349 50	1,349 50	1,349.50	1,500 00	3,500 00	3,500 00	3,750 50	2,750 50	25,000
TELECHRONS	3,080.80	640 00	400 00	560 00	400 00	1,560 00		40 00	5,040.00	1,240 00	920 00	6,120 00	20,000
WAFFLE IRONS	360 00	5,030 00	2,120 00	370 00	380 00	360.00	330'00	360 00	370 00	5,030 00	2,180 00	1,100 00	18,000
PERCOLATORS	570 00	330 00	180 00	4,690 00	1,670 00	380 00	330 00	190.00	330 00	330 00	330 00	1,670.00	11,000
COOKERS			28 00	210 00	560 00	5,320 00	3,334 00	896 00	56.00			196 00	10,500
FLAT IRONS	300 00	410 00	505 00	600 00	1,930 00	1,045 00	835 00	2,050 00	835 00	410 00	320 00	1,010 00	10,250
TOASTERS	290.00	100 00	1,850 00	580 00	240 00	240 00	255 00	255 00	255 00	165 00	165 00	1,105 00	5,500
SPACE HEATERS	410 00	205 00	140 00						135 00	450 00	2,250 00	1,410 00	5,000
TOTALS	$36,519 25	$80,272 50	$88,835 50	$92,791 25	$105,060 75	$99,090 75	$100,198 50	$54,796 00	$105,808 50	$97,107 50	$47,085 50	$92,434 00	$1,000,000

Fig. 7. Sheet No. 7 of Quota Book.

QUOTAS
by districts and appliances

District	Refrigerators	Ranges	Washers	Radios	Ironers	Vacuum Cleaners	Water Heaters	Lamps	Telechrons	Waffle Irons	Percolators	Cookers	Flat Irons	Toasters	Space Heaters
ASTORIA	42	90	100	30	60	45	75	6,000	33	100	66	45	135	66	60
BEND	66	105	150	50	70	52	87	8,000	35	150	77	53	145	77	70
Dayton-Waitsburg	38	60	80	30	40	30	50	4,000	22	60	44	30	80	44	40
ENTERPRISE	38	60	60	30	40	30	50	4,000		60	44	30	80	44	40
GOLDENDALE	17	30	32	10	20	15	25	1,750	12	30	22	15	40	22	20
GRANGEVILLE	38	60	60	30	40	30	50	4,000	22	60	44	30	80	44	40
HOOD RIVER	30	90	100	30	60	45	75	6,000	30	100	66	45	125	66	60
LEWISTON	81	120	170	40	80	60	100	8,000	43	170	88	60	160	88	80
Pasco-Kennewick	30	90	100	30	60	45	75	6,000	30	100	66	45	125	66	60
PENDLETON	30	90	100	30	60	45	75	6,000	30	100	66	45	125	66	60
POMEROY	17	30	32	10	20	15	25	1,750	12	30	22	15	40	22	20
PROSSER	17	30	32	10	20	15	25	1,750	12	30	22	15	40	22	20
SEASIDE	17	30	32	10	20	15	25	1,750	12	30	22	15	40	22	20
SHERMAN	38	60	60	30	40	30	50	4,000	22	60	44	30	80	44	40
SUNNYSIDE	38	60	60	30	40	30	50	4,000	22	60	44	30	80	44	40
THE DALLES	30	90	100	30	60	45	75	6,000	30	100	66	45	125	66	60
TOPPENISH	30	90	100	30	60	45	75	6,000	30	100	66	45	125	66	60
WALLA WALLA	96	140	200	60	95	70	117	9,000	47	200	105	70	200	105	95
YAKIMA	112	175	252	50	115	88	146	12,000	58	260	126	88	225	126	115
TOTAL	800	1500	1800	500	1000	750	1250	100,000	500	1800	1100	750	2050	1100	1000

Fig. 8. Sheet No. 8 of Quota Book.

WE CAN GET THAT MILLION
These figures show it!

DISTRICT	1928 Sales	1929 Quota
ASTORIA	$ 29,049.64	$ 57,210.00
BEND	104,068.95	78,705.50
DAYTON-WAITSBURG	24,698.47	37,250.00
ENTERPRISE	35,956.78	36,370 00
GOLDENDALE	18,828.96	19,752.50
GRANGEVILLE	31,894.87	37,250.00
HOOD RIVER	37,529.00	56,230.00
LEWISTON	69,142.30	88,670.00
PASCO-KENNEWICK	46,600.91	56,230.00
PENDLETON	37,828.08	56,230.00
POMEROY	13,396.09	19,752.50
PROSSER	14,265.98	19,752.50
SEASIDE	7,128.35	19,752.50
SHERMAN	60,826.59	37,250.00
SUNNYSIDE	28,886.67	37,250.00
THE DALLES	37,647.43	56,230.00
TOPPENISH	49,612.56	56,230.00
WALLA WALLA	66,194.93	103,188.75
YAKIMA	78,517.42	126,695.75
TOTAL	$792,071.98	$1,000,000.00

Fig. 9. Sheet No. 9 of Quota Book.

LEWISTON'S

PART IN THAT MILLION

APPLIANCE	NO. OF PIECES	AVERAGE PRICE	TOTAL
Refrigerators	81	300 00	24300 00
Ranges	120	150 00	18000 00
Washers	170	125 00	21250 00
Radios	40	150 00	6000 00
Ironers	80	67 25	5380 00
Vacuum Cleaners	60	50 00	3000 00
Water Heaters	100	20 00	2000 00
Mazda Lamps	8000	25	2000 00
Telechrons	42	40 00	1680 00
Waffle Irons	170	10 00	1700 00
Percolators	88	10 00	880 00
Cookers	60	14 00	840 00
Flat Irons	140	5 00	800 00
Toasters	88	5 00	440 00
Space Heaters	80	5 00	400 00
		Total	88670.00

Fig. 10. Sheet No. 10 of Quota Book.

How are the dollars in LEWISTON for JANUARY

	QUOTA	SALES	+	−
REFRIGERATORS	600 00			
RANGES	150 00			
WASHERS	375 00			
RADIOS	1200 00			
IRONERS	67 25			
VACUUM CLEANERS	50 00			
WATER HEATERS	20 00			
MAZDA LAMPS	140 00			
TELECHRONS	240 00			
WAFFLE IRONS	30 00			
PERCOLATORS	40 00			
COOKERS				
IRONS	25 00			
TOASTERS	20 00			
SPACE HEATERS	35 00			
MISCELLANEOUS				
TOTAL	2992 25			

Fig. 11. Sheet No. 11 of Quota Book.

How are the dollars in so far this year?

LEWISTON

TO END OF	QUOTA	SALES
January	2992.25	
February 2 months	7222.00 10214.25	
March 3 months	8117.00 18331.25	
April 4 months	8427.50 26758.75	
May 5 months	9256.50 36015.25	
June 6 months	9134.50 45149.75	
July 7 months	9364.25 54514.00	
August 8 months	4479.50 58993.50	
September 9 months	9704.00 68697.50	
October 10 months	8475.00 77172.50	
November 11 months	3839.50 81012.00	
December 12 months	7658.00 88670.00	

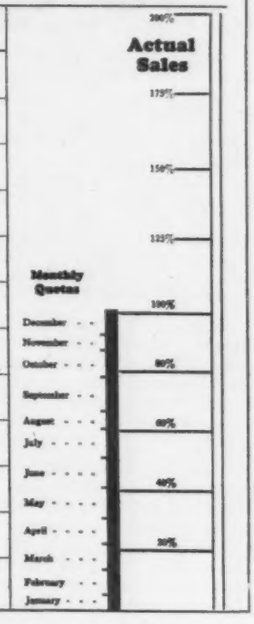

Fig. 12. Sheet No. 12 of Quota Book.

Proof of the Pudding for LEWISTON'S Appliance Sales

		Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
Refrigerators	Quota	2	2	6	18	9	18	10	5	4	2	2	3	81
	Sales													
Ranges	Quota	1	3	5	4	30	12	30	12	4	2	2	15	120
	Sales													
Washing Machines	Quota	3	34	26	4	6	4	4	8	42	34	3	7	170
	Sales													
Radios	Quota	6	2	1	1		1	1		2	6	10	8	40
	Sales													
Ironers	Quota	1	12	12	2	2	2	1	2	20	20	2	4	80
	Sales													
Vacuum Cleaners	Quota	1	1	24	16	3	3	3	1	1	1	1	3	60
	Sales													
Water Heaters	Quota	1	2	2	3	25	10	25	10	3	2	2	15	100
	Sales													
Mazda Lamps	Quota	560	480	480	480	400	400	400	480	1120	1120	1200	880	8000
	Sales													
Telechrons	Quota	6	1	1	1	1	3			11	8	2	13	42
	Sales													
Waffle Irons	Quota	3	46	20	8	4	3	3	3	4	48	21	10	170
	Sales													
Percolators	Quota	4	3	1	27	13	3	3	2	3	3	3	13	88
	Sales													
Cookers	Quota				2	3	30	18	5	1			1	60
	Sales													
Irons	Quota	5	6	8	10	30	16	13	32	13	6	5	16	160
	Sales													
Toasters	Quota	4	2	30	9	4	4	4	4	4	3	3	17	88
	Sales													
Space Heaters	Quota	7	3	2						2	7	26	23	80
	Sales													

Fig. 13. Sheet No. 13 of Quota Book.

Page 5 is a listing of the names, numbers and average selling price of the appliances making up "That Million." Items are arranged in proportion to their total resale value. (Fig. 5.)

Page 6 shows the year's quota of appliances for the entire company broken down into monthly quotas. (Fig. 6.)

Page 7 shows a broken-down version of the total quota in dollars for each appliance by months. (Fig. 7.)

Page 8 assigns definite yearly quotas on each item to each of the company's nineteen districts. (Fig. 8.)

Page 9 (Fig. 9) shows a comparison between 1929 quotas and 1928 sales for the purpose of allowing each district to see the increase necessary in its merchandising effort to reach its 1929 quota. It also illustrates the statement on page 2, which is: "We have attempted to assign to each district a part of 'That Million' which will be a just division of the total quota and which will penalize no one for previous jobs well done," since in some instances the 1929 quota is less than the 1928 sales. In other words, it is recognized that these particular districts did an outstanding job in 1928.

Page 10 is the first of the four individual district sheets. The following four sheets in the book apply to the individual district's quota, while the first nine pages may be considered as reference pages and are common to all books. Page 10 lists the name, number and average price of the appliances making up the individual district's "Part in That Million." (Fig. 10.)

Page 11 is an entry sheet on which the current month's quota is broken down into appliances. The district enters in the sales column its sales of appliances opposite quota. The plus and minus columns are, of course, the difference between sales and quotas. The sheet gives at a glance an analysis of the district's business for the current month as compared to quota. Similar sheets are furnished for each month of the year. (Fig. 11.)

Page 12 shows each district its own cumulative quota by months and provides space in which to enter its sales by months and cumulatively so that at all times the relation between quotas and sales is apparent. The quota graph on the right-hand side of the page is divided in the proportion that each month's quota bears to the year's quota. The sales column is filled in as each month's business is finished. (Fig. 12.)

Page 13, the final page or "Proof of the Pudding," is, we believe, an important one. On this page all appliance quotas are broken down into monthly quotas and monthly sales are entered in spaces provided. This sheet furnishes a complete record of quotas and sales of all appliances. (Fig. 13.)

A master quota book, containing the individual pages of all of the nineteen districts, is made up and kept in the main office. Necessary entries are made in it to keep information useful to the main office up to date.

The quota sheets are furnished to the individual districts in leather ring binders. The binder is a peranent one and new quota sheets are to be made each year.

An addition to the contents of the present quota book is planned for next year. This new sheet will be called a Revenue Sheet and will furnish each district with the estimated annual revenue resulting from the attainment of its merchandising assignment.

Qualifications for Rural Selling*

SINCE most activities are 90 per cent man and 10 per cent plan, the electric farm equipment subcommittee has centered largely on the qualifications a rural salesman should have.

There are a few qualities which every man should have if he is to embark on a selling career. This applies whether he is selling merchandise, a service or what not. He should be a student, courteous, equipped with some patience and diplomacy, and have vision. Starting from this basis the experience of several public service companies in the Northwest tends to show that a rural salesman should have—

First: A sympathetic understanding of farming and a belief in its future.

Second: Ability to discuss intelligently his company's rates, policies, etc., particularly as applied to rural districts.

Third: Knowledge of the practical uses of electricity on the farm, and the lesser problems of servicing electrical equipments.

Perhaps it is too much to expect to have all of these characteristics in one man.

We, in the public service company work, have come to expect rather large results in a short time. The growth of our industry has been enormous the past few years. The rural population is almost our last frontier. Millions upon millions of dollars are being, and will be, invested in plants, transmission, substations and distribution, in order that the American farmer may receive the benefits of high line service. He is not familiar with either our service or our organization. He has been reading and hearing many unfavorable things concerning us.

Selling electricity to the farmer means that he must first be sold on the idea that he is being asked to do business with an industry that has no intention of misleading him, and one whose sole endeavor is to cooperate with him in getting electric service on his farm. He must be impressed with the fact that an economic problem is involved on both sides: first, that income must square with outgo, and some additional to take care of contingencies, if the public service company is to develop this business to provide adequate service at reasonable rates, due to the comparatively low density of customers on rural lines; second, that our business is a long pull proposition, and we are interested only in seeing that the farmer installs efficient equipment such as will enable him to secure the maximum results from the use of our service, since once we have made the investment to serve him, it can be made profitable to us only by his continued use of it over a considerable period.

If, in outlining the qualifications a rural salesman should have, your committee has set up a supersalesman, it has seemed to us that, taking all angles into consideration, it will require a high class man to do a good job.

The sooner a good job is done, the sooner the farmer will have all the benefits electric service offers him, and the sooner rural electrification will be put on a sound, financial basis.

Selling has built up an urban customer acceptance to the point where electric service of some types, is considered as important as plumbing and heat. Selling is, after all, the only thing that will secure the same results in rural territory. It requires a little wider knowledge of equipment and possibly a better understanding of customer problems. When you sell a farmer what he can economically use in electric equipment you are touching him on both the domestic and commercial sides.

American business did not attain its present world's status by filling the business man's home with electric equipment. Electricity in business has been one of the main reasons. An electrified farm does not mean a houseful of domestic equipment. That is a large part, but not all of the job. Mrs. Farmer is quite often the accountant of the firm. She knows what the income has been and what the prospects are. She is a member of clubs and organizations which study methods of improving living conditions in farm homes, as well as net profit on farm operations. She knows much about Mr. Farmer's business while the average urban home-maker knows very little about her husband's affairs.

The average farmer is loyal if he receives good service. He is perhaps our best booster. It takes good salesmen to sell good service. A wonderful opportunity awaits our industry in putting the advantages of electricity within the reach of one of our greatest businesses—agriculture. We can't afford to allow mediocre salesmen to be our representatives. "Satisfied and friendly rural customers" is our goal. It will take good men to bring this about.

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* Report of electric farm equipment subcommittee—J. C. Baldridge, Idaho Power Company, chairman. Pacific Power & Light Company: R. B. Bragg. Puget Sound Power & Light Company: R. W. Clark. The Washington Water Power Company: J. F. Farquhar.

POWER BUREAU

Commercial Cooking*

IN THE report of the commercial cooking committe at the midwinter conference of the Commercial Section, the experiences of many individual power companies in the promotion of the commercial cooking and baking load were presented. These experiences are condensed herein.

Potential Market

It is gratifying to note that the commercial cooking and baking load in the territory has shown a very rapid increase since 1926. However, analysis shows that there is a still greater potential market waiting to be tapped. This is particularly true of the cooking load. The baking load has grown rapidly in the last few years, and bakers have accepted the electric oven as the most practical, but there is still considerable pioneering to be done in commercial cooking.

To point out the potential market for the commercial cooking and baking load, we have been able to compile some very interesting data through the co-operation of the U.S. Department of Commerce, the Bakers' Association, the Sperry Flour Mills, and the Northwest central stations.

In the states of Oregon and Washington, there are 962 bakeries doing a business of over $6,000 per year. There are a total of 1,448 ovens of all kinds, of which 413 are electric, which is a saturation of 28.5 per cent, with an average monthly revenue of $90 per oven, with a 2 cent rate prevailing.

Analysis of the commercial cooking load, however, does not indicate that such good results have been obtained in exploiting this field. According to the analysis compiled through the co-operation of the Washington Department of Health, Stewards' Association, and the kitchen supply houses, there are 10,014 public eating places, with only 167 electric installations, which is a saturation of 1.67 per cent. These electric installations yield a yearly revenue of $225,450, averaging approximately $112.50 per month to the power companies. Of this total of 167 installations, there are 125 heavy duty electric ranges in use, which alone produce a yearly revenue of $74,250, or an average for each range of $49.50 per month.

The total annual power bill paid to central stations by the electric commercial cooking and baking installations in the states of Oregon and Washington is approximately $671,490.

From a survey made by the kitchen supply houses of the Northwest, Stewards' Association and other fuel equipment manufacturers, we learn that 90 per cent of the commercial kitchens are equipped with gas, and that the fuel bills of the different types of installations are as follows:

		Av. Fuel Bill Per Installation Per Month	Total Fuel Bill Per Month	Total Fuel Bill Per Year
Gas installations	9,012	$75	$675,000	$8,110,800
Oil installations	75	30	2,250	27,000
Wood, Coal and Steam	760	50	38,000	456,000
Electric installations	167	112	18,787	225,450
Total	10,014			$8,819,250

Population, Washington and Oregon, 2,489,000.
Per capita, 249 persons per public eating place.

These data give a fairly good picture of how the present use of electric energy for commercial cooking compares to the use of other fuels, and indicate what the total possibilities are.

Because of the low saturation of 1.67 per cent, the commercial cooking load offers a very large potential market for one of the most desirable power loads the central stations can place on their lines, as the characteristics of this load are that it has 100 per cent power factor, has a load factor of from 40 to 60 per cent, and is about 70 per cent off peak.

Central Station Practice

In the Northwest there are a number of central stations that actually merchandise commercial cooking and baking equipment, and that have shown a very substantial merchandising profit in building this profitable connected load. These central stations employ a heavy duty specialist, who calls regularly on the bakery, hotel and restaurant trade, with a complete coverage every 60 days. In order to simplify or segregate the classifications of hotels, restaurants, institutions, etc., heavy duty survey cards, are used, which give the heavy duty specialist a ready reference.

In promotion by the central stations of sales of commercial cooking and baking equipment, there is very little newspaper advertising done, the principal medium being direct mail advertising by means of broadsides and literature furnished by central stations and manufacturers.

Where the central stations themselves do not actually merchandise heavy duty equipment, there is someone designated to act in an advisory capacity in co-operating with the kitchen supply houses and the equipment manufacturers.

Influence of Kitchen Supply Houses

It should be of considerable interest to the power companies to know of the activities of the kitchen supply houses and the part they play in the promotion of the commercial cooking load.

With a force of thirty-five salesmen, these concerns cover every city and town in the states of Washington, Oregon, and part of Idaho, building up a wide acquaintance in the hotel and restaurant field. In recent years they have come to accept electric equipment as practical for use in commercial cooking, and like all other good merchandisers, are ready to promote this new business, provided the co-operation of the central stations and equipment manufacturers is received. They realize that electric energy is the coming fuel for use in commercial kitchens, because of the many conveniences and advantages over other fuels, and they have in fact been responsible for much of the increase in this type of load occurring recently.

It must be remembered that these kitchen supply houses are large corporations, and have ample financial backing, which enables them to carry large contract accounts when furnishing equipment for hotels, restaurants and institutions, which, as a class, need this kind of financial aid. The kitchen supply houses, being in a position to carry their accounts for a long period of time, thus place their clients under certain obligations and so can sell practically any type of equipment they suggest, whether it be gas, coal, oil or electric equipment. Therefore, it behooves the power companies and equipment manufacturers to co-operate with these concerns in building a commercial cooking load.

Program of Kitchen Supply Houses

The sales campaign which the kitchen supply houses have outlined for the promotion of commercial cooking and baking equipment during this year are interesting.

The principal feature of this campaign is the all-electric kitchen exhibit and demonstration to be held in Spokane, Seattle and Portland, where actual cooking is to be done by a chef, to prove the quality of food cooked electrically and to show the practical use of electric equipment for commercial cooking. The entire sales force of the kitchen supply houses will center their efforts on these shows, bringing their customers in to see them.

Their plans also call for a complete coverage of all the central stations and dealers in the Northwest by their sales representatives for the purpose of establishing friendly relations which will be of mutual benefit in increasing the commercial cooking and baking load.

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* Report of commercial cooking committee—**C. J. Anderson**, Edison Electric Appliance Company, chairman. **Mountain States Power Company:** Glenn L. Jackson. **Northwestern Electric Company:** R. W. Faville. **Portland Electric Power Company:** A. B. Chambers. **Puget Sound Power & Light Company:** Wm. Clancy, R. L. Grant. **Utah Power & Light Company:** Geo. P. Traynor. **The Washington Water Power Company:** Carl Hoffman.

Objections to Electric Cooking

It might be well to mention why electric cooking does not have a more ready acceptance with the hotel and restaurant trade, which can be summed up in four outstanding reasons, as follows:

1. Because electric energy is the newest kind of fuel in commercial cooking, and being new is mistrusted.
2. Practicability—Many people believe electric equipment for commercial use is too slow. Heating elements will not stand up under hard usage. Repairs and replacements are too expensive. It is too complicated to operate. Fear of power shut-down.
3. First cost of electric equipment—Three to four times higher in cost than other fuel equipment. Cost of wiring and installation.
4. Operating cost—Two to three times higher than other fuel.

Advantages

There are some advantages in favor of other fuels, but many more advantages in favor of electric equipment for commercial cooking, which can be summed up as follows:

1. Less shrinkage results in substantial saving in weight of products.
2. Less spoilage. Products stay fresh longer than when baked or cooked with flame fuels.
3. Less danger of fire and explosion.
4. Lower insurance rates.
5. Elimination of costly flues and stacks.
6. Less attendance required.
7. Ease and convenience of control.
8. Year around constant pressure.
9. Uniform heat and products.
10. Saving in floor space.
11. Cleanliness and better sanitary conditions.
12. Cool bakeshop and kitchen.
13. Satisfaction of employees and patrons.
14. Standard design, adaptable anywhere.
15. Superior construction, practically indestructible.
16. Minimum depreciation.
17. Saving in labor.
18. Material saving in decorating costs.
19. Advertising value.

This report has been made possible by the co-operation of the various equipment manufacturers, flour mills, U. S. Department of Commerce, Washington Department of Health, Union, Standard, and Associated Oil Companies, Pacific Coast Coal Company and the central stations of the Northwest.

Industrial Heating*

THE central station companies have in industrial heating perhaps the greatest potential load of all the different sorts of load. It has been estimated to be 100 per cent greater than the present power load including that of the isolated and private plants. This greater potential load can be secured by the central station companies using the same methods which they followed in developing their lighting and power business. It is the purpose of this report to outline a plan of procedure and show a few of the possibilities awaiting development.

A decision as to the desirability, from the utility standpoint, of the electric industrial heating load would be based in the main on the same general considerations inquired into of any other prospective normal business, which finally resolve themselves into a question of the "net from operation" to be secured. Leading up to an indication of what this item might be are the following questions:

1. Size and permanency of the available load.
2. Electrical and operating characteristics of the load as affecting utility production costs.
3. Cost of facilities for and the securing of the business.
4. Revenue available and rates necessary to secure the business.
5. Effect on our public relations.
6. Sales plan.

It is, of course, not hoped that in the space available in this paper we may be able to develop a general formula for the solution of each individual case, but rather to indicate a procedure, draw out a discussion of further details and develop the problem as it applies to our industry as a whole.

Size and Permanency of the Available Load

It is conservatively estimated by "Electrical World" that there is at the present available nationally betwen 40 and 50 million kw. connected load of industrial heating; this from the use only of equipment already developed and backed with satisfactory performance records. These figures do not include those deferred loads, which, for one reason or another, are not satisfactorily solved. It should be further stated that the field available has no accurately defined limits, due to constantly improved equipment being made available, increased knowledge as to its performance, better understanding of the customer's requirements, decreasing cost of electric service, etc., so that an application considered in the "deferred" class today may be in the definitely "available" class within the year.

As to the size of this load in any particular district, this it would seem, can only be ascertained by a careful analysis of the territory. The committee this year sent to each one of its members and member companies a questionnaire which was made in the type of a survey to obtain a cross-section of the present heating load in this geographic division. From the ten representative companies solicited, there was but one reply that they had upon their system an industrial heating load of 50 kw. or over. It appears that in those sections of the country having a large number of metal trades, there in a sizable industrial heating load, and we seem unfortunate in not having sufficient metal trades for capitalizing upon this type of industry. It should not be assumed, however, that non-industrial districts are barren, for such is not the case. A considerable volume of miscellaneous and small wattage applications are possible generally even in these districts. A survey was recently made by one of the manufacturers of electric products of a city in the middle-west, the results of which showed that steel melting added 7,400 kw. connected; heat-treating steel, 8,200 kw. connected; and that baking operations and miscellaneous applications of electricity contributed 8,200 kw. connected. It would appear, therefore, that one-third of the available market is outside of the metal trades.

As to the permanency of the load, reports from those using the service where it has been properly and advisably installed, indicate a satisfaction with the results secured, that the displacement of this service in most cases would be possible only through the development of superior and at present unknown processes. It should not however, be taken from this that the service can be sold and then left to "paddle its own canoe," but rather that, as in other branches of our industry, contacts with the managers as well as operators of the processes should be maintained and the benefit of any advice or other assistance given, if the relations are to be the most satisfactory.

Electrical and Operating Characteristics of the Load As Affecting Utility Production Costs

The industrial heating load possesses several characteristics that from this standpoint make it perhaps one of the most desirable loads today. It is a high load factor load, even higher than motor load, a considerable portion being 24-hour load, and much of it is off peak. The larger portion of the load, both present and prospective, operates at unity or very high power factor. This sometimes so improves the individual power customer's poor power factor as to remove the imposition of poor power factor penalties.

The effect of unity power factor industrial heating load on customer's power factor is indciated very clearly in a recent published statement by one of our larger electrical manufacturers. With an assumed motor load of 1,000 kw. at 80 per cent power factor, the power factor resulting from additions of unity power factor heating load would be:

Industrial Heating	Power Factor (Per cent)
Present 1,000 kw	80
Addition of 200 kw	85
Addition of 500 kw	89.5
Addition of 1,000 kw	93.5

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* Report of industrial heating committee—R. W. Faville, Northwestern Electric Company, chairman. **The California Oregon Power Company:** J. C. Thompson. **Edison Electric Appliance Company:** R. P. Segurson. **Idaho Power Company:** J. B. McLain. **Puget Sound Power & Light Company:** Thos. M. Gibbes. **Utah Power & Light Company:** G. B. Walker. **The Washington Water Power Company:** Carl Hoffman.

Cost of Facilities For and the Securing of the Business

Due to the higher power factor at which this load operates, the corresponding plant, lines and substation investments are less than those supplying a like kw. of power load.

The cost of securing the business, the sales expense, etc., are undoubtedly generally greater than present similar items of securing power business, due to the greater familiarity of our customers, as well as ourselves, with motor power problems, and the fact that a large portion of our present industrial heating work is still in the nature of pioneering work in many districts.

Revenue Available and Rates Necessary to Secure the Business

Present annual national revenue from industrial heating developed runs well over $50,000,000. Partially due to the higher load factor at which this load is rendered it shows better than 25 per cent greater average revenue per kw.-year (based on instaled capacity) than the average earnings from motor power. Of interest also is the fact that although operating at a higher load factor, but possibly due to the smaller total load involved, industrial heating secures a higher average revenue per kw.-hr. than motor power estimated at 1.7 cent per kw.-hr. against motor power at 1.4 cent per kw.-hr.

It is estimated there is a total annual revenue of better than $1,250,000,000 (the next to the largest source of available and additional revenue known at present) available from this one source to the utility industry. From the supply of the present available national load, yielding an average of approximately 1⅓ cent per kw-hr. at a rate range, said by those who have made a careful study of competitive conditions involved, of 1 cent to 2 cents per kw.-hr.

Effect On Our Public Relations

Adverse effect on public relations, due to the assuming of industrial heating loads involved, would probably occur only from the question of lower competitive rates granted this development or in case of unsatisfactory performance of customer's equipment. In the first case it is held that the average rate per kw.-hr. necessary to secure this business is but slightly under that earned or secured by present industrial heating connected load. That the lower charges necessary to secure the present available business reach no lower level than that at present enjoyed by a portion of the utility load and that the average rate contemplated is well above that already earned in railroad applications.

In regard to the second possibility, unsatisfactory performance of customer's equipment, equipment with satisfactory performance records is available for the contemplated loads. Its selection and installation is a matter of personnel and management, together with co-operation with reliable experienced manufacturers having a background of satisfactory business dealings

Sales Plan

The economies of electric heating over other fuels in its field of application have been covered by previous reports submitted and by surveys made to member companies by the N.E.L.A. Detailed discussion of this phase is, therefore, omitted.

The items which contribute mainly to our operating and sales effort are: first, temperature control is absolute; second, regulation is automatic; third, constant operating conditions are assured which result in a multitude of savings in production and labor to our customers.

The committee feels that the field of application, although dormant at the present time in the Northwest, will respond to intelligent sales effort and compensate the central stations for any expenditures made in this line of work. The national committee has submitted reports on all phases of industrial heating loads and given adequate information for the carrying on of sales effort, if the sales effort is properly applied. The industrial heating committee wishes to submit the following sales plan:

First, that one or two men from each organization be detailed to the development of the industrial heating work and educate themselves in the various applications, sales points, and design of the heating equipment, and be so prepared that they may design unusual applications themselves or have competent engineers able to do this work upon whom they may call.

Second, that an intelligent survey be made of each power consumer of major importance, that this survey be analyzed and used, not only for the industrial heating work, but also for the power salesman's information and reference. The benefits to accrue from such a survey are apparent and are of material benefit to the central stations, for the survey will further a better business relationship by calls on the part of the central station representative; will be an index of the competitive power situation; and may be used as an indication of the customer's business and his operation.

Third, that central station executives be willing to spend money for the development of one of the largest potential loads on our systems at the present time. The willingness of the company to spend money for experimental work will start the ball rolling over a few applications which will become accumulative in their effect.

We have endeavored in this report to bring attention to the desirabiity and reasons that the central station industry should exert effort and attention to the development of electric heating in industry. A great deal of time could be spent upon working out definite sales plans, but we have endeavored in this report to submit the essential requirements which we believe should be incorporated in every commercial department.

Let us hope that you are not forgetting the power man's difficulties of 15 or 20 years ago when your prospect, a business man too, really believed what he said when he told you "that little chunk of iron is too small to run my plant" and you had to convince him by actually belting the motor, "that little chunk of iron," to his line shaft and operating his plant at a better speed regulation, lower over-all power cost, etc., than he had been able to operate it previously. Who of us, forgetting past difficulties in other fields of development, such as motor applications and more recently electric ranges and domestic electric refrigeration, are impatient with the progress being made in the field of industrial heating, and shy off at demonstration or trial installations and some of the other expedients used heretofore to overcome prejudices, lack of information and other sales resistance? Why should we not expect some difficulty in displacing the present used competitive equipment supplied in the main by well organized national industries? Why should we expect business of the magnitude of 40 or 50 million kw. representing one and one-quarter billion dollars annual revenue, to be handed us on a silver platter?

Power Equipment*

IN A CHOICE of subjects for this season's work, the Power Committee considered only those which are of particular interest to power companies of the Northwest in connection with some of the basic industries of the Northwest.

1. The general status of competition with isolated plant power:
   (a) Diesel engines, in general.
   (b) Steam turbo-generators in sawmills and in pulp and paper plants.
2. Plant equipment, operating practice and economics of
   (a) A typical electric-driven irrigation plant
   (b) A typical pre-cooling plant
3. Some requirements of salesmanship in industrial power work.

Diesel Engines

In a survey of this subject, it was found that practically all the data available to the committee is identical with or closely parallels that presented in "Diesel Oil Engine Power Costs" which is the serial report of the National Power Committee for 1926-1927. No noteworthy installations have been made in this territory since that time, the information is so well presented in the previous committee's report.

It is interesting to note that our industry and the oil engine people have been able to get together in a conference and arrive at a somewhat better understanding than has existed in the past, and this condition is re-

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* Report of power committee—**L. R. Grant,** Puget Sound Power & Light Company, chairman. **Pacific Power & Light Company:** W. H. McMurray. **Puget Sound Power & Light Company:** J. R. Percival. **The Washington Water Power Company:** A. G. Wegner,

flected to some extent in the official Diesel publication, "Diesel Oil Engine Power."

The Diesel engine has its own province as a prime-mover, under certain conditions for the generation of electric power. It will be recalled that at one time the gasoline engine was a competitor of central station service, particularly in small installations. Such competition is no longer a considerable factor due to its own limitations and good salesmanship on the part of the power companies. The gasoline engine today has its own undisputed field. It seems reasonable to predict that the oil engine will follow the same course.

Steam Turbo-Generators

From the standpoint of the power company, the matter of competition with isolated plants in sawmills is more a matter of competition with a waste product which must be disposed of. For the mill man, it is obviously more economical to install a boiler plant and turbo-generator than to nistall a refuse burner. For this reason it has been, and to some extent still is, more difficult for central station power to make headway in the lumber industry than in any other common to the Northwest.

The question of the sale of power to sawmills was very thoroughly covered in the report of the Power Committee in 1925 and that part of the report dealing with the disposal of mill refuse was most prophetic in the light of present-day conditions. What was once considered waste, to be destroyed or utilized in generating power, has become a valuable commodity. In Seattle, and other cities, the use of sawdust and hogged fuel for domestic and industrial space-heating has become so widespread that there has recently been an actual shortage of such fuel. Methods of preparing this fuel so as to insure a fairly uniform heat value, and of storing and transporting it have so improved that its commercial value is increasing. Some progress is also being made in the extraction of oils and various other products from the waste of woods common to this territory.

It seems certain that eventually there will be no such factor as "waste" and the problem of its disposal in the lumber industry.

Another factor favorable to the power company is that many of the older mills are reaching the full capacity of their own power plants and that some of their equipment is obsolete. The matter of outlay and of capital charges for additional equipment or for complete new equipment is a serious question to the mill man. This is particularly true considering the state of the lumber market during the past few years of overproduction and low prices.

Considering all of the above, there has been no more favorable time for the introduction of central station service in the sawmill than the present, and a study of the mills in this territory should well repay the power salesman. Each mill presents a somewhat different problem due to the varying degrees in which a shortage in the mill's own power plant exists. It is recognized that power must be sold to sawmills at comparatively low rates, and consequently that part of the mill's operations having a comparatively high load factor, such as blowers, planers, conveyors and sorting tables, is generally the best suited to central station service. The fact that one power company now has connected to its lines over 15,000 hp. in sawmills and shingle mills, some of which are wholly operated by its electric service, is indicative of what can be accomplished.

The pulp and paper industry offers a different problem. In this case large quantities of steam must be provided for various processes of manufacture an dif the steam can first be used to generate power as a by-product, the cost of steam and power per unit of manufactured product is thereby reduced. The Proceedings of the Technical Association of the Pulp & Paper Industry shows that its members are very much alive to the power question. They have a light, heat and power committee which is continuously engaged in studying it, and a constant effort is being made to reduce the unit cost. They are close observers of the trend in steam generation of power by the electric companies. The result is a consistent effort to increase efficiencies not only by installing new equipment but through more efficient operation of present equipment.

The steam required for manufacturing processes is ample to generate all the power needed, but the difficulty is to develop the necessary power when and as required and at the same time provide the necessary steam at the various pressures when and as required, and do both efficiently. The bleeder or extractor turbine has been used in an effort to accomplish this. Steam is taken from the turbine at the desired pressure, the quantity being automatically controlled by proper valving. This practice results in a greatly increased water rate per kw.-hr. which in turn increases the boiler capacity over what would be necessary for either power only or steam for process purposes only.

As stated above, the engineers in this industry are observing closely the trend in steam generation of power by electric service companies. They have noted the tendency to go to higher pressures and the greater efficiencies thereby obtanied in the generation of power. As a result a similar tendency is developing in the pulp and paper industry. In place of the bleeder turbine and its condensor, higher pressure turbines exhausting at 100 to 125 lb. back pressure are being advocated and introduced. Exhaust steam at these pressures is adequate for the cooking process and can be reduced to lower pressures for the other processes. One of the difficulties encountered under this system is to synchronize the necessary amount of steam with the necessary amount of power. To provide the peak load of process steam, a steam accumulator is advocated, and it is claimed that the cost of a higher pressure turbine operating at 100 lb. back pressure and an accumulator is not as great as the cost of a bleeder turbine, with its condensor.

The foregoing shows in a general way something of the power problems in the pulp and paper industry. It would indicate that a certain amount of purchased power may be used at a profit to both buyer and seller. In the Pacific Northwest, the pulp and paper industry is in its infancy and since this territory contains the greatest remaining supply of pulp wood in the United States, it is bound to grow very rapidly. At the present time there are nineteen pulp, paper and paper board mills operating and twelve more building or planned.

A comparatively small amount of power is now being sold to pulp and paper mills by electric service companies, and in a few instances is the bulk of power required by any one mill thus supplied. The Everett Pulp & Paper Company is a notable instance, in which practically all power requirements have been purchased since 1912. If electric service companies are to invade this field, a much more extended and careful study of power costs and the related problem of process steam cost must be made than could be carried out by this committee.

Irrigation and Pre-Cooling Plants

It was the intention to present a description and records of at least one typical plant of each kind which would be of use for comparative purposes. In endeavoring to secure information on irrigation pumping, it was found that none of the plants available for study use meters for measurement of water pumped. Without such records no study would be of sufficient value to present, and as this is not the irrigation season, any such study must therefore be deferred until summer. Referring to pre-cooling plants a similar lack of accurate records was encountered, and this subject must likewise be deferred.

Salesmanship In Industrial Power Work

In considering the possibilities of central station power in the lumber and the pulp and paper industries, it is evident that only the highest type of salesmanship, backed up by engineering knowledge, will produce favorable results. So much has been written about salesmen and salesmanship that it may appear venturesome for a power committee to discuss the matter, but certainly some features of the power salesman's requirements for the above work will bear emphasis. The usual requirements of a good salesman—personality, honesty, alertness, industry—all of these are necessary, but they are not quite enough in competition so close that one or two mills per kw.-hr. is the deciding factor in getting the business or losing it, which is often the case in selling to the industries named in this paper.

The salesman who would make progress in this field must himself have either a sound engineering knowledge, or enough of it so that he can understand and talk intelligently, backed up by the wholehearted support of the engineering staff of his company. It must be considered that the engineers and managers of indus-

tries like sawmills and pulp plants are "hard-boiled," to use a common term, without any disrespect whatever, and in the sense that they must be shown, and shown in terms more or less peculiar to their industries. They have been in the business a long time, a longer period than that in which central station service or even electric power has been an important factor in any business. They have an extensive experience, both theoretical and practical, to draw upon and some of them observe traditions of their business, which the power saleman must handle intelligently and warily. All this is by way of saying that the salesman must know enough of the sawmill business and the pulp and paper business, theoretically and practically, to secure the interest of his prospect and assure a sympathetic hearing.

But one sympathetic hearing will seldom secure the business. What will secure it, if anything will, is what may be called "intelligent persistence." This involves establishing a friendly contact, a personal or business friendship, or both, that will make the salesman welcome to call frequently on the prospect. The frequency of such calls cannot be prescribed, but in number and in nature must be such that a friendly interest is sustained and the prospect finally convinced that the salesman has something of mutual advantage to offer. Too much stress cannot be laid on this matter of repeated friendly contacts, and contacts that do not for a moment lose sight of their business objective. The man who can thus conduct himself is entitled to the name of "Power Sales Engineer," and he will seldom fail.

Engineering Section Reports

EXECUTIVE COMMITTEE*

DURING the past year there have been held three two-day meetings and one luncheon meeting of the executive committee of the Engineering Section, Northwest Electric Light and Power Association. The first meeting was held for the purpose of organizing the various regular committees and outlining the work for the year. The other meetings had to do primarily with the conduct of the affairs of the section and with arrangements for the annual general meeting, which was held in Walla Walla, Wash., in March.

Special Committees

There was organized early in the year a subcommittee of the hydraulic power committee for study of fishways and control of migratory fish. J. E. Yates, Pacific Power and Light Company, was appointed chairman of this committee. He was also later appointed chairman of a subcommittee on fishways of the N.E.L.A. hydraulic power committee. The purpose of this committee was to carry on the work of experimenting with various types of fishways and various methods of controlling the movements of migratory fish.

There was organized a special code committee under S. B. Clark, Northwestern Elecaric Company, as chairman. This committee was organized for the purpose of studying national safety code problems and to tie in with the national code and standards committee. P. S. Arkwright, president of the N.E.L.A., requested that the various member companies throughout the country and the various geographic divisions make an extra effort this year to study code matters giving particular consideration to the 1928 National Electrical Code relative to electric wiring and apparatus as sponsored by the National Board of Fire Underwriters. A number of features in this code have met with opposition by various companies and the Engineering Sections of the various geographic divisions. It is hoped that through the concerted efforts of the many code committees which have been organized recently, that a satisfactory wiring code eventually will be adopted.

Neon Signs

During the past two years there has been a tremendous increase in the use of Neon signs. Owing to the peculiar characteristics of Neon gas tubes it is necessary to operate them from high-voltage, high-impedance transformers. This combination results in a very low power factor. It was believed by the members of the executive committee that an investigation should be started with the hope of determining ways of equipping these signs with the necessary corrective apparatus so that they would operate at a satisfactory power factor. It was hoped that sufficient interest would be aroused so that the power companies would insist that the manufacturers of Neon signs would so equip the signs that they would be satisfactory with respect to power factor. This problem was turned over to the electrical apparatus committee.

Radio Interference

There is considerable radio interference caused from high-tension insulators. Much experimentation has been carried on to develop high-tension insulators that would not cause troublesome radio interference. There are many high-tension lines in existence, however, equipped with insulators that are causing radio interference. It was thought advisable therefore to attempt to determine effective and economical means of clearing these lines of this troublesome characteristic. It was suggested that a test line be constructed in some suitable place where experiments would be carried on. This special work has been turned over to the inductive coordination committee.

National Meetings

The first N.E.L.A. engineering group meeting was held in Philadelphia, Pa., October 8-12, 1928. The engineering section sent three delegates to this meeting, E. H. Collins, The Washington Water Power Company; T. A. Purton, Idaho Power Company; and D. W. Proebstel, Portland Electric Power Company. O. L. LeFever, Northwestern Electric Company, was in the East at that time and found it convenient to attend the meetings. During the meeting Mr. Collins presented the fishway problem mentioned above to the national hydraulic power committee and solicited its aid in carrying on investigations. Mr. Proebstel presented the subject of Neon sign low power factor to the national electrical apparatus committee and was assured by the chairman that a thorough study of the problem would be made.

The second annual group meeting was held at Memphis, Tenn., March 11-14, 1929. Two delegates were sent to this meeting, W. S. Hill, Grays Harbor Railway and Light Company, and C. H. Hoge, Puget Sound Power and Light Company. Mr. Collins happened to be in the East at this time and attended the meetings.

Reciprocity with P.C.E.A.

The executive committee, through a special arrangement with the Pacific Coast Electrical Association, whereby delegates would be exchanged, authorized the sending of one delegate to the April meeting of the P.C.E.A. Engineering Section, which was held in Fresno, Calif., April 17-19, Mr. Proebstel being the delegate.

N. B. Hinson of the Southern California Edison Company, Los Angeles, chairman of the P.C.E.A. Engineering Section, and L. J. Moore, San Joaquin Light and Power Company, Fresno, attended the March meeting at Walla Walla, as delegates from the P.C.E.A.

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* **D. W. Proebstel,** Portland Electric Power Company, chairman. **E. F. Pearson,** Northwestern Electric Company, vice-chairman. **The California Oregon Power Company:** J. C. Thompson. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Grays Harbor Railway & Light Company:** W. S. Hill. **Idaho Power Company:** T. A. Purton. **Montana Power Company:** H. H. Cochrane. **Mountain States Power Company:** Z. E. Merrill. **Northwestern Electric Company:** S. B. Clark, O. L. LeFever. **Pacific Power & Light Company:** H. H. Schoolfield, J. E. Yates. **Peoples West Coast Hydroelectric Corporation:** M. V. Watson. **Portland Electric Power Company:** A. H. Kreul, C. C. Simeral. **Puget Sound Power & Light Company:** C. H. Hoge, G. E. Quinan. **Utah Power & Light Company:** J. A. Hale. **The Washington Water Power Company:** E. H. Collins, J. B. Fisken.

General Meeting

The sixth annual general meeting of the engineering section was held in Walla Walla, Wash., March 25-27, 1929. This was a three-day meeting, at which papers were presented on many of the engineering problems with which the utilities have to deal. The various committees presented their portion of the program consisting of papers and open discussion. The papers, together with discussions, will appear in printed form in the bulletin of this general meeting which will be distributed to members of the section at a later date.

Reports summarizing the work of the various committees of the section and their programs at the Walla Walla meeting follow.

ACCIDENT PREVENTION COMMITTEE*

LAST year the opening paragraph of the report of the accident prevention committee stated that during the year very little had been accomplished except to co-operate with the national committee. This year that statement might be repeated with the omission of the reference to co-operation with the national committee.

The fact that the national committee has not sought co-operation from this committee during the past year does not imply that it has been inactive. As a matter of fact the national committee has been very active, but as its activities no doubt are fully covered in the report to the national convention, they need not be discussed here.

While it is true that the local committee as a body has been inactive the individual members have not. There has been a very healthy growth in accident prevention work and this is evidenced not only by the safety work of the individual members, but by the interest taken in that work by many of the company executives.

Accident Statistics

One of the most important subcommittees of the N.E.L.A. accidental prevention committee is the statistics subcommittee.

As the collection of statistics has been a severe burden on the subcommittee and as the importance of accident statistics from an economic viewpoint has been fully recognized, arrangements have been made whereby the collection of data will be undertaken by the N.E.L.A. headquarters staff, and the duty of this subcommittee will be the analyses of results collected at headquarters.

The results as tabulated annually by the subcommittee will be the measure of the effectiveness of the work of the accident prevention committee and all member companies should make it their duty to furnish data promptly and fully; these should include data on frequency, severity, fatalities and costs.

It is expected that a serial report will be ready for submission at the June meeting of the national committee.

At a meeting of this committee held at Walla Walla during the sixth annual general meeting of the engineering section in March it was decided that all member companies should be requested to furnish the chairman of the committee full data on all accidents during the six months periods ending January 1, and July 1 of each year; that the chairman should prepare an analysis of these reports and should issue this analysis in bulletin form to all members of the committee and to all member companies, no company names to be stated. The value of such a report will depend upon the measure of co-operation by the member companies.

Resuscitation

The standard text for prone-pressure artificial respiration became available in the fall of 1927 and during 1928 the green booklet was issued by the American Gas Association and the National Electric Light Association. By November, 1928, about 7,500,000 of these booklets had been placed in circulation.

On Aug. 4, 1928, an article by Dr. William Brady appeared in a group of some 50 syndicated newspapers and was followed on September 25 by another article. In these articles Dr. Brady challenged the correctness of certain details of the technique, which created some uneasiness and resulted in correspondence with Sir Edward S. Schaefer. As a result of this correspondence it is expected that an effort will be made to revise the procedure and to issue a new booklet.

During the past year many fatalities have resulted from electric shocks which could have been prevented had anyone of those who were on the scene of the accident been familiar with the Schaefer prone pressure method of resuscitation, and the same thing is true in connection with drowning and gas asphyxiation accidents. It would be very desirable if the member companies would furnish to all their customers instructions as to what to do in cases of asphyxia.

Insull Medal Awards

In last year's report mention was made of the application for the award of an Insull Medal to Don B. Thompson by the Pacific Power and Light Company. This application was approved by the N.E.L.A. executive committee and the presentation was made to Mr. Thompson by L. A. McArthur, vice-president and general manager, Pacific Power and Light Company, at the Washington State First Aid Contest held at Tacoma, Aug. 11, 1928. This was a very impressive ceremony and created a great deal of interest among the crowd present.

During the past year applications have been made for the award of Insull Medals to two employees of our member companies, and advice has just recently been received from headquarters that the executive committee of the N.E.L.A. has approved these applications.

These applications were in favor of Andrew J. Huling, an employee of the Portland Electric Power Company, who saved the life of a fellow employee who had been asphyxiated by electric shock, and L. E. Danks, an employee of the Mountain States Power Company, who was successful in restoring respiration to an employee of one of that company's customers after he had received an electric shock, though unfortunately the victim in this case died from physical injuries which he received when he fell from a pole.

No arrangements have been concluded yet for the presentation of these medals.

First Aid

It is gratifying to be able to report a continuing interest among the member companies in first aid instruction of employees.

The Pacific Power and Light Company will hold its regular first aid contest in May and it is probable that The Washington Water Power Company also will hold an intra-company contest in May.

It is desirable that the member companies should arrange for an annual inter-company first aid contest since such a contest undoubtedly would be heartily welcomed by the employees and the small expense incurred would be repaid many fold in the reduction of accident costs.

Annual General Meeting

At the sixth annual general meeting of the Engineering Section held at Walla Walla, Wash., March 25-27, 1929, papers were presented by Wallace Brier, Puget Sound Power and Light Company, on the subject, "That Twenty Per Cent of Injuries," and by J. C. Henkle, Portland Electric Power Company, on the subject, "Survey of Safety First for Meter Men." Both these papers created a great deal of interest, and should be of interest to all company executives; unfortunately there was not sufficient time for a full discussion.

There also was an interesting and instructive address by G. L. Knotts, of the E. I. DuPont De Nemours Company, on the subject, "Safety in the Home, Stressing Safety Education of Youth."

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* **J. B. Fisken,** The Washington Water Power Company, chairman. **The California Oregon Power Company:** S. M. Bullis. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Idaho Power Company:** E. C. Kiersted. **Mountain States Power Company:** W. J. Mandley, Walter Smith. **Northwestern Electric Company:** J. D. Ellis. **Pacific Power & Light Company:** G. I. Drennan. **Portland Electric Power Company:** C. F. Young. **Puget Sound Power & Light Company:** W. Brier, E. H. Worthen. **Utah Power & Light Company:** F. E. Hansen.

COMMITTEE ON CO-OPERATION WITH REGULATORY BODIES*

THIS committee on co-operation with regulatory bodies has not been actively engaged in any particular work during the past year but has kept in touch with regulatory problems coming up in the different states of this section. Some work has been done in connection with the adoption of a uniform rural extension rule by the Public Service Commission of Montana and members of the committee have assisted in revising some proposed changes in various codes in the different states.

At the annual general meeting of the Engineering Section the committee's portion of the program consisted of an address by C. Rea Moore, supervisor of utilities, Department of Public Works, state of Washington, on the subject "Utility Regulation." This address was of a very enlightening and constructive nature and we believe was particularly beneficial to members of the engineering staffs of the different utilities represented at the meeting.

* **Z. E. Merrill,** Mountain States Power Company, chairman. **Grays Harbor Railway & Light Company:** H. J. Flagg. **Idaho Power Company:** J. L. Boone. **Pacific Power & Light Company:** W. T. Neill. **Puget Sound Power & Light Company:** G. E. Quinan. **The Washington Water Power Company:** G. H. Pike.

ELECTRICAL APPARATUS COMMITTEE*

UPON REQUEST of the executive committee of the Engineering Section, the electrical apparatus committee made a special study of the economics of the neon sign situation from the electrical utility standpoint. Data were obtained from surveys made by the Portland Electric Power Company and the Northwestern Electric Company of Portland, and the Detroit Edison Company, Detroit.

From data submitted on some 1,400 signs it was found that the average sign required approximately 600 watts energy and a total of 1,333 volt-amperes with a resultant power factor of 45 per cent. This low power factor makes necessary the use of considerable additional investment in synchronous condenser, transmission and distribution capital.

It was found from this study that the average neon sign costs the power company approximately $7.04 per year more than if the sign were corrected at the sign location to operate at 100 per cent power factor. Actual charges, of course, will vary with sign load and local distribution conditions.

The committee recommends that sign manufacturers and contractors equip all signs supplied in the future with capacitors sufficient to raise the over-all power factor to a minimum of 90 per cent.

The annual meeting of the apparatus committee took place at Walla Walla, Wash., on March 26, as part of the Engineering Section general meeting. Three papers were presented. One entitled "Preferred Voltage Ratings for A.C. Systems," by A. L. Harding, assistant engineer, Electric Bond & Share Company, New York, was presented by John Bankus, Portland Electric Power Company. Mr. Harding is chairman of the joint N.E.L.A. and N.E.M.A. committee on A.C. System Voltage Standards and has had a great deal of experience on this subject. The voltage standards as recommended by Mr. Harding seem reasonable and in general are acceptable to the majority of the power companies. In summing up the effects of establishing preferred voltage rating Mr. Harding says:

> The situation seems to be sufficiently advanced to warrant the manufacturers in making the change. In the long run, it should be of considerable financial benefit to the power companies through reduction in the price of standards replacing specials, because of greater quantity production and through more effective replacement and repair service. The operating benefits are better service, reduced losses and interchangeability, throughout a system and among systems. It must not be expected that immediate large savings will result, but over a long period of time the reduction in capital investment and annual operating costs should be considerable as compared with the expenditure if present practice is permitted to continue.

Another paper entitled "Some Tendencies in the Design of Station Apparatus" was presented by Charles E. Carey, supervisor of engineering, Northwest District, Westinghouse Electric & Manufacturing Company, Seattle. Mr. Carey gave an illustrated talk on all-steel switching equipment, condenser bushing potential devices, oscillograph equipment, umbrella-type generators, and deion circuit breaker.

A third paper entitled "Some Recent Electrical Apparatus Developments" was presented by C. W. Fick, Northwest district engineer, General Electric Company, Portland. Mr. Fick presented an illustrated talk on hydrogen cooled machines, double winding generators and high speed exciters.

Considerable discussion ensued following the presentation of various topics in both papers. From the viewpoint of the chairman, the outstanding topics were umbrella-type generator as offered by Mr. Carey and high speed excitation as offered by Mr. Fick.

* **E. F. Pearson,** Northwestern Electric Company, chairman. **The California Oregon Power Company:** R. S. Daniels. **Grays Harbor Railway & Light Company:** W. S. Hill. **Idaho Power Company:** E. A. Woodhead. **Montana Power Company:** J. C. Dow. **Mountain States Power Company:** G. McClellan. **Northwestern Electric Company:** Frank Lewis. **Pacific Power & Light Company:** D. R. McClung. **Portland Electric Power Company:** John Bankus. **Puget Sound Power & Light Company:** J. Hellenthal. **Utah Power & Light Company:** D. L. Brundidge. **The Washington Water Power Company:** C. B. Carpenter.

HYDRAULIC POWER COMMITTEE*

THE HYDRAULIC power committee seems to have accomplished a little more work than usual in 1928-29. The chairman attended both meetings of the national committee. One direct result of this was that we were toble to have the national committee request funds of the N.E.L.A. to help our committee carry out experiments relative to the fish problem.

In co-operation with the national committee questionnaires have been submitted to the national subcommittee on reliability of hydro-electric units. The fishway problem was adopted by the national committee and the Northwest subcommittee has been made a subcommittee of the national hydraulic power committee.

The added time allowed this year at the March meeting of the Engineering Section at Walla Walla was very much appreciated. With the extra time there was more discussion and it was necessary to continuously limit a speaker's time. The papers presented by the committee were as follows:

1. The Fishway Problem, by J. E. Yates, Pacific Power & Light Company
2. Turbine Leakage, by J. H. Siegfried, Pacific Power & Light Company
3. The Problems of Hydro-Unit Governors, by A. N. Geyer, Utah Power & Light Company

The committee was fortunate in having present C. W. Fick, northwest engineer, General Electric Company, and I. C. Martin, vice-president Woodward Governor Company, to discuss Mr. Geyer's paper. There was not enough time to complete the discussion and an evening conference was held for those interested in governors.

A report of the subcommittee on fishways as of April 1, 1929, is published herewith.

* **E. H. Collins,** The Washington Water Power Company, chairman. **The California Oregon Power Company:** Harry Olsen. **Idaho Power Company:** H. L. Senger. **Montana Power Company:** H. H. Cochrane. **Pacific Power & Light Company:** J. H. Siegfried, J. E. Yates. **Portland Electric Power Company:** C. P. Dunn. **Puget Sound Power & Light Company:** G. C. Sears, **Utah Power & Light Company:** A. N. Geyer, J. A. Hale.

Experiences in Fishway Construction*

THE REPORT of the subcommittee on fishways of the hydraulic power committee for the year 1928-29 as of April 1, 1929, will be given under two headings: (1) The accomplishments of the committee for this period, and (2) the status of the fishway situation as of April 1, 1929.

Committee Accomplishments

The most important work done by the committee was that of outlining the experiments to be conducted at the Gold Ray Plant of the California-Oregon Power Company on the Rogue River to be participated in jointly by the utilities and the U. S. Bureau of Fisheries. After several preliminary conferences between the committee chairman and the representatives of the Bureau of Fisheries a trip was made to the Gold Ray Plant on Tuesday, Nov. 13, 1928. Following this inspection it was decided to install two electric fish screens, one of these to be installed in the tailrace and the other across the intake to the plant. Inasmuch as the Bureau of Fisheries was experimenting with the electric screen patented by H. T. Burkey they expressed a desire to continue the work with the Burkey screen until they were convinced that this patent was or was not usable. In accord with this, screens of the Burkey patent are to be installed at Gold Ray.

The screen in the tailrace will be located at considerable angle with the direction of flow in the race with a trap located at the upstream end. This installation will serve two purposes: (1) a means of keeping migrating salmon and steelheads out of the tailrace and in the main channel of the river, and (2) being installed at an angle with a trap at the upper end, some information will be secured on the possibility of leading these migrating fish into a trap. Competent observers will be maintained during the period when fish are migrating at this point.

The second screen installed across the intake to the plant will keep small migrants on their way downstream out of the water leading into the plant and direct them into the main channel. The material necessary for making these two installations has been ordered and is on the ground. The installation will be begun in the near future and completed before the end of April, 1929. The expense of these two installations is being borne jointly by the utilities and the U. S. Bureau of Fisheries, each paying half of the expense.

Inspections

On September 25, 1928, a trip was made to the Oak Grove Plant of the Portland Electric Power Company in company with representatives of the Bureau of Fisheries to determine whether this development presented a suitable location for experimental work with the electric screen. Conditions at this location were not considered the best for experimental work; therefore no further action for an installation at this point was taken at the present time. On Oct. 6, 1928, the chairman and Prof. F. O. McMillan visited an experimental electric screen of the Burkey patent installed by the Bureau of Fisheries in the Tieton Canal northwest of Yakima, Washington.

Legislative Matters

The committee has rendered special service in connection with the following legislative matters up for consideration in the State of Oregon:

(1) Measures designed to close four important streams in the state from further water appropriations.
(2) A bill creating a water board to have jurisdiction over water appropriations.
(3) A measure proposing very drastic changes in the State Water Code.
(4) A bill giving the state engineer additional powers for the inspection and approval of dams.

None of these measures became laws except the last named.

Progress Reports

Progress reports covering fishway matters were submitted to the engineering section meeting of the National Electric Light Association held in Philadelphia, Oct. 8-12, 1928, and at a similar meeting held in Memphis, March 11 and 12, 1929. A report on the fishway problem was presented to the sixth annual meeting of the engineering section, Northwest Electric Light & Power Association, held in Walla Walla, March 25-27, 1929.

The chairman attended a hearing called March 15, 1929, by the Federal Power Commission to consider the application of the Washington Electric Company for a preliminary permit to investigate the power site at Rock Island on the Columbia River 12 miles below Wenatchee.

Present Status Fishway Work

As of April 1, 1929, the fishway subcommittee work can be briefly stated as follows:

Fishway Up—No decided progress can be reported for the problem of a suitable fishway up. The most pronounced example of this type of fishway is exemplified by the one installed as part of the Baker River project of Puget Sound Power & Light Company on the Baker River. The number of fish put over the dam by this fishway for each year is as follows:

1926	8,000
1927	17,500
1928	22,000

The United States Bureau of Fisheries has a hatchery on the upper portion of Baker River for the propagation of sockeye salmon. All of the 1928 sockeye run was not successful in getting over the Baker River dam, due probably to their exhausted condition when reaching the fishway brought about by having wormed their way through the intricate mess of nets and fishing gear in the Skagit River between its mouth and the mouth of the Baker River. In spite of its record in putting other species of fish over, the Baker River fishway has been branded as a failure. Last year's experience on the Baker River will probably lead to the establishment of a hatchery on the Baker River below the plant.

The Pacific Power & Light Company began operating its Lewiston plant on the Clearwater River about the first of the year 1928. The fishway installed as a part of the hydraulic works at this plant is patterned after what is ordinarily known as the pool-and-rest type of ladder. It has a maximum difference in elevation between the water below and above the dam of about 30 ft. The Clearwater River is frequented by both salmon and steelheads. This ladder operated successfully during 1928 for both steelhead and salmon. During certain hours of the day while fish were migrating observers were in attendance at the ladder and they counted more than 6,000 steelhead going over the dam. The greatest number of steelhead using the fishway during any one hour was 256 and during the 24-hour period 1200. The chinook salmon experienced no difficulty in going through the ladder though the count was not kept as accurately on this species.

Fishway Down—No progress can be reported on the success of a suitable fishway down except that experimental work now in progress with the electric screen will undoubtedly have some bearing on this problem.

Screening—During the spring of 1928 Congress appropriated $25,000 to be utilized in studying the screening of irrigation diversions for the protection of migrating fish. Shirley Baker, a consulting engineer of San Francisco, was appointed to study the problem, and is working in co-operation with the U. S. Bureau of Fisheries. After a complete review of all the work which had been done to date on this problem, apparatus was assembled and a test made of the Burkey electric screen on the Tieton ditch northwest of Yakima, Wash. The results of this test were so hopeful that the Bureau of Fisheries authorized the screening of all the government irrigation diversions in the Yakima watershed. In addition, officials of the Pacific Power & Light Company have authorized the screening of the intake to the Naches plant. As a result of this activity, there will be screened this spring the following:

Sunnyside Canal	diverting	1,500 sec.-ft.
Wapato Canal	diverting	1,700 sec.-ft.
Tieton Canal	diverting	600 sec.-ft.
Naches Canal	diverting	500 sec.-ft.

* Report of subcommittee on fishways—**J. E. Yates,** Pacific Power & Light Company, chairman. **The California Oregon Power Company:** Harry Olsen. **Oregon State College:** F. O. McMillan. **Portland Electric Power Company:** C. P. Dunn. **Puget Sound Power & Light Company:** O. P. Newberry.

and other smaller diversions, approximating a total of 4,600 sec-ft., which is more than 50 per cent of the total water diverted in the Yakima watershed.

The Tieton experiments gave very satisfactory results on the operation of the electric screen as far as small migrants were concerned and there was a desire on the part of Mr. Baker as well as this committee to secure further data on the operation of the elctric screen when larger fish were present. This led to the installation proposed for the tailrace at the Gold Ray Plant of the California Oregon Power Company on the Rogue River near Medford, Ore., as explained in the first part of the report. If the results of the experimental work at Gold Ray work out as anticipated the electric screen may be of considerable utility in the future in solving the fishway problem. If by the use of this device migrating fish can be led to a trap or other predetermined location their passage over obstructions will resolve itself primarily to the installation of suitable hoisting apparatus. We have considerable hopes for the success of the Gold Ray experiments and future fishway programs will depend largely upon the results secured from this work.

Summary

The year which has passed while not producing very tangible results has not been discouraging. Considerable preliminary work has been accomplished which will be of value in the final solution of the problem and the experimental program on the Rogue River will also be of considerable service in planning future work. One of the hopeful signs has been the interest which has been awakened in this problem with the Engineering National Section. The national hydraulic power committee, at its Memphis meeting, requested the Engineering Section to incorporate as a part of its 1929-30 budget, $1,000 to be used in carrying forward the fishway work.

The Wenatchee hearing demonstrated that developments involving the use of water from the more important streams on the Pacific Coast will be protested by fish culturists as longs as the present uncertainty regarding the effect of the changed conditions on biological life remains. This hearing also stressed the necessity for carrying through to completion a carefully planned co-operative program to establish the limits of the fish-way problem.

METER COMMITTEE*

SEVERAL subjects were investigated during the year concerning problems in this district. In addition much information was supplied on subjects which the national committee had under consideration.

National Committee Matters

In order to bring about closer co-operation with the national committee, all questionnaires and surveys from that committee requesting information on various subjects were sent to each local committee member for reply. Favorable comment from national subcommittee members was expressed on this plan as a much wider range of ideas and methods was secured.

D. W. Proebstel represented the meter committee at the October, 1928, meeting of the Engineering National Section at Philadelphia and gave a detailed report on the development of new devices and meters. The necessity of standardizing the new method of stroboscopic testing of meters in the near future was emphasized.

Education of Metermen

The course for electrical metermen was announced as ready for distribution in January, 1929, by the national committee and much interest has been shown by member companies requesting information in detail on this course. One company reported that 50 per cent of the metermen already had subscribed for this course, while several other companies were of the opinion that the coming fall and winter months would show much demand for the course.

At a round-table discussion of the meter committee at the Engineering Section meeting at Walla Walla, Wash., in March, 1929, the question of establishing a short course for metermen at some educational institution during the coming year was discussed. It was pointed out that the Northwest district was the only geographic division at present in which such a short course was not held. Opinion was not averse to holding the course, although there was some question on the results in view of the new national committee course now being distributed.

Safety First For Metermen

A survey of Safety First methods used by metermen was made by the committee and presented by J. C. Henkle, Portland Electric Power Company, at the Engineering Section meeting. Conclusions showed that metermen are much interested in studying first aid methods and that operating companies are allowing sufficient time for proper inspection of tools and equipment as well as spending money on the installation of safety equipment that cannot otherwise be justified as an investment. Seventy-seven accidents were reported among 126 metermen during the last five years, with a loss of 1,586 man-hours. The effects of these accidents showed that about as many were the result of cuts, bruises and sprains as were the result of electric shocks and burns.

Calibration and Use Of Rotating Standards

An investigation into the methods of calibrating and testing rotating standards among member companies in this division was made and presented by L. D. Snow, Puget Sound Power & Light Company, at the Engineering Section meeting. The tendency is growing toward the calibration of the rotating standards being done by laboratory men instead of being done by the meter tester using the standard in the field. One company is experimenting with a photo-electric cell and head phone called the "click method" in testing meters, so arranged that a click is heard for each revolution of the standard meter, thereby eliminating the personal error of starting and stopping the standard meter which runs continuously.

An experimental test of personal errors among ten men showed that the error in testing with the same rotating standard averaged less than 0.2 per cent on full load, and less than 0.4 per cent on light load.

Metering Neon Signs

Because of the low power factor in Neon signs an investigation into the metering of this class of load was made and showed that none of the companies at present had found a satisfactory method of metering the total energy supplied.

The opinion is expressed that some corrective apparatus should be provided by makers and users of such signs to improve the power factor and place it on a par with other appliances and devices.

Excess Demand Metering

Large power contracts which call for measurement of kw.-hr. at different steps of demand present a difficult problem in satisfactory metering and these difficulties were pointed out in a paper presented by L. H. Kistler, Northwestern Electric Company, at the Engineering Section meeting. A meter which accurately registers the kw.-hr. on a dial register at different block intervals of demand is more convenient and suitable for reading and billing than a curve-drawing or tape recording instrument which requires much calculating.

Service Entrance and Meter Loop Requirement

Insufficient requirements in electrical codes for service entrance and meter loops in small rural and sub-

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* **A. H. Kreul**, Portland Electric Power Company, chairman. **The California Oregon Power Company:** S. M. Bullis. **Grays Harbor Railway & Light Company:** A. J. Gravelle. **Idaho Power Company:** H. Waterman. **Montana Power Company:** E. W. Williams. **Mountain States Power Company:** C. R. McLean. **Northwestern Electric Company:** L. H. Kistler. **Pacific Power & Light Company:** R. M. Freeman. **Portland Electric Power Company:** J. L. Watson. **Puget Sound Power & Light Company:** R. E. Thatcher. **Utah Power & Light Company:** W. J. McMinn. **The Washington Water Power Company:** J. G. Finley.

urban districts caused an investigation to be made into all state and city code requirements in this division. This was presented by R. M. Freeman, Pacific Power and Light Company, at the Engineering Section meeting. The summary of these various requirements is very extensive and will prove a good foundation on which to construct a standard set of requirements for presentation to code-making agencies.

Color Code For Secondary Wiring

Several companies now are using colored wire for secondary wiring from transformers to meters to simplify making proper connections where such wiring is concealed. An attempt is being made to standardize on a code of colors among the member companies in this district before the use of such wire becomes too extensive and varied.

PRIME MOVERS COMMITTEE*

DURING the last year considerable effort has been expended by the prime movers committee in collecting data towards the preparation of a final report covering a survey of the low grade "Western lignites." This study has been under way for some time and should be in readiness for presentation at the 1930 general meeting of the Engineering Section.

At this year's general meeting, the following papers were presented:

"1929 Development at Lincoln Station of Northwestern Electric Company at Portland, Oregon," by Tom Perry.

"The Predrying of Hog Fuel," by W. A. Struthers.

"Description of Cast Iron Water-Cooled Grate Bar," by J. E. Yates.

These papers will be published in the proceedings of that meeting and are worthy of further study.

In addition to the foregoing, this committee collaborated with the various subcommittees of the national prime movers committee in the securing and tabulating of various data required by the national committee.

* **C. C. Simeral,** Portland Electric Power Company, chairman. **C. C. Moore & Company Engineers:** H. S. Bastian. **Grays Harbor Railway & Light Company:** W. S. Hill. **Mountain States Power Company:** W. C. McLagan. **Northwestern Electric Company:** Thos. Perry. **Pacific Power & Light Company:** J. E. Yates. **Portland Electric Power Company:** W. Brenton. **Puget Sound Power & Light Company:** John McEwell. **Utah Power & Light Company:** J. A. Hale.

OVERHEAD SYSTEMS COMMITTEE*

THE ACTIVITY of the overhead systems committee this year has been largely devoted to study of three subjects, namely: "Engineering for Rural Electrification," "Application of the National Electric Safety Code," and "Wood Poles."

The subject of rural electrification is engrossing the attention of electrical public utility executives and engineers throughout the entire country. In parts of our Western country rural electrification has made rapid advances on account of lines being built for irrigation pumping, and also on account of the progressive and pioneer spirit of the Western utilities. Because of this rural electrification is further developed in the Northwest than it is in many other parts of the United States, and is going forward at a rapid rate, so that the study of the engineering involved is of considerable importance.

The engineering largely falls on the distribution department, and for an extensive campaign along this line complete re-adjustment of the ordinary distribution department is necessary in order to handle the work effectively and economically. R. E. Gale of the Idaho Power Company read a paper on "The Engineering of Rural Electdification" at the general meeting of the Engineering Section at Walla Walla on March 25. Considerable discussion of the entire matter was brought up.

Another subject which is of considerable concern to all those having to do with the construction of overhead lines is the use of and application of the National Safety Code which is now in effect in most of the Northwest states. It has been found extremely difficult to interpret and use the code in actual everyday construction and design. The reason for this apparently is that it is too comprehensive, and in the attempt to cover a multitude of possible kinds of construction the more simple everyday applications are buried in a mass of printed material. R. J. Davidson of the Pacific Power & Light Company in his paper at the Walla Walla meeting demonstrated in a very clear manner what could be done in the way of representing a great many of the ordinary applications of the code in a graphical manner.

The subject of poles is one of considerable importance to all those concerned with overhead lines and is one which is becoming of greater importance every year. A great deal of experimenting is in progress on different kinds of poles treated in various ways. For several years this committee has been giving attention to this subject. This year the matter of the use of Douglas fir poles with a full-length creosote treatment was considered by Dan L. Lindsley, of the Pacific Creosoting Company, Seattle. His paper not only discussed the use of Douglas fir poles, but also the value of full-length treated poles for use in the Northwest on account of termites. The impression has been rather general throughout the Northwest that termites were not a serious menace in this territory. Mr. Lindsley declared that he has found considerable evidence of termite activity along the Northwest Coast and in Portland, Seattle and other cities.

The chairman of this committee attended the general meeting of the Engineering National Section in Philadelphia on Oct. 8-9, and C. H. Hoge attended the Overhead Systems Committee meeting at Memphis, Tenn., on March 11-12. An attempt has been made to keep up the overhead systems committee map of the entire Northwest territory, and the tracing of this map is now held by the chairman.

* **T. A. Purton,** Idaho Power Company, chairman. **The California Oregon Power Company:** R. S. Daniels, C. D. Wood. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Graybar Electric Company:** Harry Bilica. **Grays Harbor Railway & Light Company:** F. J. Robbins. **Idaho Power Company:** R. E. Gale. **Montana Power Company:** A. C. Pratt. **Mountain States Power Company:** Walter Smith. **Northwestern Electric Company:** D. A. Hord. **Oregon State College:** F. O. McMillan. **Pacific Power & Light Company:** R. J. Davidson. **Portland Electric Power Company:** A. B. Cayo. **Puget Sound Power & Light Company:** M. T. Crawford, C. L. Hill. **Utah Power & Light Company:** P. P. Ashworth. **The Washington Water Power Company,** L. R. Gamble.

UNDERGROUND SYSTEMS COMMITTEE*

THE FIRST work of the underground system committee, whose members represent six utility companies, was the gathering of data from the Northwest geographic division for the chapter on "Cable Splices and Terminals" in the "Underground Systems Reference Book," of which R. C. Hooke is assistant editor. Sketches and descriptive matter covering methods of splicing all types of cables and the mounting of cable terminals were sent in by the various committee members.

As most of the member companies have installed or are interested in a.c. underground network systems, the committee felt that a description of the systems in use would be interesting and instructive. Accordingly, three papers were prepared and presented at the an-

* **C. H. Hoge,** Puget Sound Power & Light Company, chairman. **Idaho Power Company:** H. M. Jones. **Northwestern Electric Company:** S. B. Clark. **Portland Electric Power Company:** J. M. Gillham. **Puget Sound Power & Light Company:** F. E. Fisher. **Utah Power & Light Company:** P. P. Ashworth. **The Washington Water Power Company:** F. L. Rohrbach.

nual general meeting of the Engineering Section held at Walla Walla, Wash., March 25-27, 1929. They were: "Ring Feeder System of A.C. Underground Distribution at Spokane," by F. L. Rohrbach; "Use of Translators in A.C. Underground Networks" by F. E. Fisher; and "A.C. Secondary Networks" by H. Richter, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Mr. Richter happened to be on the Pacific Coast at that time and kindly consented to contribute to the meeting. These papers brought out many questions and much interesting discussion.

The committee chairman attended the national underground systems committee meeting at Memphis, Tenn., March 13 and 14, 1929.

Public Relations Section Reports

EXECUTIVE COMMITTEE*

A report from the executive committee of the Public Relations Section of the Northwest Electric Light and Power Association naturally implies a summing up and an appraisal of the situation of our industry in respect to its relations with the public as well as a recounting of our activities for the association year 1928-1929. The organization of the section was constituted on the following basis:

Executive Committee
Advertising and Publicity Committee
Committee on Co-operation with Educational Institutions
Customer Ownership Committee
Committee on Employees' Relations With the Industry
Committee on Employees' Relations With the Public
Public Speaking Committee
Committee on Relations With Financial Institutions
Women's Committee.

Fourteen members comprised the personnel of the executive committee, which included the chairman of the section, the vice-president of each of the five states embraced in the association, and the chairmen of the eight functioning committees.

Acting on the recommendation of last year's Executive committee, who pointed out that the functions of the pubilc information committee were too extensive to obtain the best results, that committee was abolished and in lieu thereof there have been created two committees, one, a public speaking committee and, second, a publicity advertising committee.

The executive committee of the section at its initial meeting for the association year, which was held in Seattle Aug. 23, 1928, very carefully considered and approved a program of activities for each committee.

Advertising and Publicity Committee

The purpose of the advertising and publicity committee is to provide an exchange of ideas and material among interested member companies pertaining to publicity in general and good will advertising in particular. Chairman J. H. N. Adams, Mountain States Power Company, and his associates have been making a study to determine the best advertising being done in merchandising, stock and institutional advertising of member companies. They have also made contact with the Public Utility Section of the Pacific Coast Advertising Club and are giving thought to the important matter of how best to capitalize on the money being expended by member companies on radio advertising. This committee also hopes to determine what means are most effective for bringing to the public the fact that the light and power industry is spending considerable money to provide attractive radio programs. The committee is also impressed with the importance of co-operating with commercial organizations in small towns, helping such organizations to advertise their communities, which I am sure is a very desirable form of public utility publicity.

Committee on Cooperation With Educational Institutions

The functions of the committee on co-operation with educational institutions are to bring about a closer understanding and better methods of education with reference to public utilities in the higher institutions of learning. Pending completion of a survey being conducted by the national committee, whose report has not yet been completed, it was deemed advisable by Chairman W. P. Strandborg, Portland Electric Power Company, and his committee members, to defer definite action of our Northwest geographic committee until the results of the national survey have been made available.

Customer Ownership Committee

The customer ownership committee of our association was organized some years ago to assist and encourage electric light and power companies to put into practice the policy of selling their securities to customers; to accumulate for the benefit of member companies the methods of putting on customer ownership campaigns and compiling records of securities sold through said campaigns; to issue a standard of practice on the sale of securities to customers; and to compile a salesman's handbook for instruction in selling utilities' securities. While it is true that a number of member companies of the association have temporarily discontinued their customer ownership activities because general conditions have made other forms of financing preferable, our committee has, nevertheless, under the chairmanship of E. G. Jarvis, Portland Electric Power Company, kept in touch with the situation and is making a report of progress for the association year now ending.

Committee on Employees' Relations With the Industry

The committee on employees' relations with the industry was brought into being for the specific purpose of making a study in the interest of mutual understanding between employees and employers and to make available records of experience with plans and methods designed to accomplish such purposes; to foster through the activities of member companies the proper education of employees in the fundamental economic principles of the light and power business, in the proper understanding of inter-relation of the public and the industry, and in the proper handling of complaints and courtesy to the public; and to foster the activities of company employee organizations. This work during the past year has been under the able leadership of Chairman E. C. Kiersted, Idaho Power Company.

Committee on Employees' Relations With the Public

The work of the committee on employees' relations with the public was aptly outlined in chairman George L. Myers' report for the last association year. It is necessarily largely determined by the relations of the employees to the industry. If we hope to have employees voluntarily do more than what is demanded of them in their respective vocations toward building up and maintaining satisfactory public relations, encouraging a greater and more diversified use of electricity and in encouraging local investment in securities, it is necessary that there be some tangible evidence of appreciation by the management through an appropriate policy and providing for social contacts, comforts, convenience, advancement and security. This committee, with E. L. Bourne, Utah Power and Light Company, as its chairman, in cooperation with the women's committee has sponsored as one of its major activities for the current association year, an essay contest on the subject, "Pleasing Mr. and Mrs. Public",

* **W. H. Ude**, The Washington Water Power Company, chairman. **R. B. King**, Idaho Power Company, vice-chairman. **Idaho Power Company**: E. C. Kiersted. **Mountain States Power Company**: John H. N. Adams, W. B. MacDonald. **Pacific Power & Light Company**: Geo. L. Myers, S. E. Skelley. **Portland Electric Power Company**: E. G. Jarvis, W. H. Lines, W. P. Strandborg. **Puget Sound Power & Light Company**: N. W. Brockett, Mrs. Nell Laws. **Utah Power & Light Company**: Col. E. LeRoy Bourne, P. M. Parry.

which has proven very successful in that it has interested a large number of employees who have participated in the contest. The winning paper in the men's division will be read at the convention.

Public Speaking Committee

As has been very ably pointed out by the N.E.L.A., the purpose of the public speaking committee is to assist in the dissemination of facts regarding the electric light and power industry primarily to employees and to qualify employees to address other groups when requested. It is axiomatic that employees well informed regarding the industry for which they work render better service to their employers and to the public than those who are not, and that public speaking is an effective means of self-development. It is felt that much misunderstanding is caused by lack of understanding of facts or by misinformation. A duty devolves upon those in the industry because of its quasi-public character, to provide and make available reliable, accurate and timely information. The scope of the committee, therefore, is to organize in such manner as to permit of specific concentration on subjects pertaining to our industry and to assist in the training of employees of the industry so that they may be well qualified to present factual information regarding the industry through the spoken word.

Because of the widespread interest taken in last year's public speaking contests which were participated in by a gratifying number of employees of member companies on the subject of "Government in Business" and "The Public Utility's Place in the Community", under the direction of our Public Information Committee, it was the consensus of opinion that this particular activity be again sponsored by the section this year, in view of which two distinct public speaking contests, open to employees of Class "A" members, were approved. In Class I local and district agents were eligible to compete on the subject of "The Public Utility—A Good Citizen," while in Class II all other employees except officials and general office department heads, were permitted to participate on the subject, "How Can I Best Serve Our Customers?" Chairman S. E. Skelley, Pacific Power & Light Company, will be called upon during the convention for a report of this activity, and we will also be afforded an opportunity of listening to the winners in these contests, which will convince us of the importance of this particular activity.

Committee on Relations With Financial Institutions

The committee on relations with financial institutions has heretofore functioned independently of the Public Relations Section, but has been made a part of the section's organization so as to conform with the organization of the Public Relations Section of the N.E.L.A., as recommended by last year's chairman. The function of this committee is to encourage understanding and establish relations between the public utility and the financial institutions, with specific emphasis being laid on the value of close relations between the utility and the local bankers. Vice-president W. H. Lines of the Portland Electric Power Company, has been chairman of this committee during the past year, and with the cooperation of his associate members, has kept in proper touch with the situation and reports that the relations of the industry with financial institutions have been very harmonious throughout our entire geographic division.

The women's committee of our Northwest Geographic Division has had a most successful year under the able leadership of Mrs. Nell Laws, Puget Sound Power and Light Company. While this committee was organized for the specific purpose of formulating and putting into effect plans for the education of the women of the country in the fundamental economic principles of the electric light and power business and the inter-dependence of the public and the industry, they have in addition thereto cooperated in every possible way to make the past year the best in the history of our association. From the splendid achievements of this committee during the past five years, we see a greater variation in its aims, a more complete understanding by individual members of utility principles and problems; a deeper sense of appreciation of their relation to the industry and the public; and a greater conception of what constitutes public good will. The women of our Northwest Geographic Division are now far more able to understand and cooperate with the present day advances in the social, political and economic world as affecting the industry in which they are employed and the communities in which they serve.

This committee has played an important part in our essay contest on the subject, "Pleasing Mr. and Mrs. Public," sponsored jointly by the women's committee and the committee on employees' relations with the public, and will present the winning paper chosen from the women of the industry at this convention.

General Remarks

All recommendations made by the governing committee of last year's public relations executive committee, were adopted except the recommendation which suggested that consideration be given to the creation of a permanent committee to be known as "The Committee on Legislation and Taxation", which would function under the Public Relations Section, and its personnel would consist of the state vice-presidents.

Inasmuch as such a committee could well undertake a study and analysis of legislative proposals and enactments among the respective states and make suggestions as to needful legislation and facts and recommendations with reference to taxation, it is requested that consideration be given to this recommendation by the incoming administration of the Public Relations Section. As has been pointed out by last year's executive committee of this section, the proposed committee, if brought into being, should co-operate with the research committee of the Accounting Section, which has for some time been making an exhaustive study and analysis on the subject of "Public Utility Taxation", which information should prove to be of much value to a committee such as is suggested, as well as to those who will make representations before legislative and civic bodies.

It is further recommended that all of the existing committees of the Public Relations Section be continued because, generally speaking, I believe we have a greater interest today in the good feeling, good standing and good will that should exist between the public and our industry. I am proud to be engaged in a work, the purpose of which is to stimulate a better understanding between our industry and the thousands of people it serves.

It has been encouraging to me to know that our efforts have been successful to an unusual degree, and that the public is growing to understand the light and power industry of this country which attempts to serve them, in a better way than has ever been accomplished before, and that out of it we will build a bigger and better industry, one that will serve continuously better as time goes on.

WOMEN'S COMMITTEE*

THE women's committee, Northwest Division, is continuing its work along the lines established, viz: Toward the end that utility women may be informed in matters relating to the principles of the industry so that they may be enabled to advance public information and aid in establishing good will and confidence between the companies and the public they serve.

Initial Meeting

The first meeting of the association year was held in Aberdeen, Wash., as guests of the Grays Harbor Railway & Light Company. At this meeting the chairman, Mrs. Nell Laws, gave a report of the meeting of the national women's committee, held in Chicago, which she attended in September. The national committee recommended that the various divisions stress the study of "The Economics of Utilities", also that

* **Mrs. Nell Laws,** Puget Sound Power & Light Company, chairman. **The California Oregon Power Company:** Mildred Knight. **Eastern Oregon Light & Power Company:** Mrs. Irma Thiessen. **General Electric Company:** Martha O. Goldapp. **Grays Harbor Railway & Light Company:** Esther Miller. **Idaho Power Company:** Mrs. Gertrude McDevitt. **Mountain States Power Company:** Estella Dorgan. **Northwestern Electric Company:** Mrs. A. W. Angell. **Pacific Power & Light Company:** Thelma Kelly. **Portland Electric Power Company:** Marguerite Butler. **Utah Power & Light Company:** Mrs. Evva O. Moyle. **The Washington Water Power Company:** Mary K. Walsh.

as in the past, the improvement of public good will should be foremost in our plans for activity. Among important ways of accomplishing this were mentioned the conitnual effort toward improvement of employee relationships and toward encouraging our members to do all possible to assist in giving the best possible service to the public. The idea of courtesy, both in personal and telephone contacts, was again emphasized. At the national meeting it was urged that the women's committee become in no way commercialized, but that it continue as in the past as an organization for the purpose of educating our women regarding the fundamental principles of the industry and the best means of giving good service to the public.

It was announced that an essay contest would be carried on this year jointly with the committee on employees' relations with the public, for both men and women employees, but with separate prizes and judges.

The committee instructed the chairman to collect the winning essays from the twelve competing committees in last year's women's committee contest, and have them prepared in booklet form, in sufficient quantity for distribution to the individual members in all Northwest committees. It was found that the regular budget allowance would be ample to finance the required expenditure.

Mid-Year Meeting

The mid-year meeting was held in Walla Walla, Wash., February 25, at which time progress reports were given and ideas exchanged regarding the various activities of the women's committee.

Essay Contest

Tentative rules and regulations had been worked out by the chairman in regard to the essay contest to be sponsored jointly by the women's committees and the committee on employees' relations with the public. W. H. Ude, chairman, Public Relations Section, sent a letter requesting that a decision be reached as to a suitable subject for the essays, dealing with "service." The subject finally decided upon was "Pleasing Mr. and Mrs. Public."

The chairman, immediately upon retiring from the Walla Walla meeting, sent out the essay announcements to all committees. At the same time the booklets entitled "The Women's Role in Public Relations" containing the winning essays from last year's essay contest were sent out to the chairman for distribution to the members. It is hoped that the booklets will be helpful in getting under way this year's contest.

Representation on National Committees

In addition to the membership of the present chairman on the national women's committee, we have two members-at-large on this committee from the Northwest: Marguerite Butler and Mary K. Walsh, both former chairmen of the Northwest committee. Miss Butler also holds membership on two other national committees, i.e., the accident prevention committee and the customer relations committee. The Northwest Women's Committee is kept in touch with the activities of these committees through this contact.

Subcommittees

National subcommittees are represented on the Northwest committee as follows: Estella Dorgan, home service committee; Martha Goldapp, manufacturers' committee; Thelma Kelly, safety committee; Mary Walsh, publicity committee.

Home Service

Miss Dorgan announced that her committee would this year get out a Home Service Scrap Book to be displayed at the convention at Atlantic City. The Home Service Department of which Miss Dorgan is the directress, of Mountain States Power Company, is getting out, in attractive booklet form, a series of seasonal food suggestions, including other valuable information, for the use of their customers, at "Christmas Time", "Easter Time", "Picnic Time" and "Canning Time." A number of the women's committees have put on successfully, home service demonstrations of appliances, refrigerators and ranges.

Manufacturers' Representative

The purpose of this representation is to develop cooperation between women of electric service companies and of manufacturer companies toward accomplishment of the purpose of the program of the general women's committee. This subcommittee in our Northwest division offers its services to secure needed information regarding electrical appliances, their construction and use. A number of educational films are available to the committee through the courtesy of the manufacturers.

Safety Committee

Thelma Kelly is in touch with the national committee and has information available for committees who wish to take up first aid word. Practically all of the northwest committees are doing work along this line, some having entered competitive contests.

Publicity

Mary K. Walsh is in charge of the work of reporting new items of the Northwest division, women's committee, for publication in the N.E.L.A. Bulletin.

Scrap Books

All the Northwest chairmen are collecting clippings, photos, and other interesting material to be arranged in scrap book form by the chairman for the purpose of exhibiting in a concrete way the activities of the Northwest committee. Similar books are in preparation in the other geographic divisions and all will be shown at the national convention at Atlantic City in June. Later these scrap books will revert to their respective divisions.

Company Committee Activities

Practically all companies hold monthly meetings covering educational programs, in many cases the entire meeting being in charge of the women. Such subjects as "Public Utility Management", "Systematic Saving", "The Personality of a Corporation", "The Office Girl of Today", "Electricity on the Farm", "The Contribution of the Public Utility to the Community", "Steam Power vs. Hydraulic Power", "Why I Find My Job Interesting", "Electrical Current Events", and many others have been discussed at the meetings by men and women from both within and without the industry.

Some of the committees have been entirely responsible for the production of a number of their company magazines.

Playlets on utility subjects and educational films have had places on the programs.

A number of the committees are active in athletics, having basketball, bowling and baseball teams, and sponsoring swimming, gymnasium and other classes for the benefit of the members.

Others are active in public speaking, cooking and art classes, utilizing electrical subjects and methods.

Committees have been made responsible for arrangements in connection with company dances, Christmas tree parties and other entertainments, budgeting the expenses and appointing all committees; also of special show window displays.

Work in connection with social responsibilities of the companies is frequently assigned to the women's committees. A great deal of charity work at Christmas time is also undertaken by them and good work has been done in this respect in practically all committees, thus proving ourselves "citizens wherever we serve."

Specialties

A number of the committees have been called into service to assist their company publicity departments in the presentation of programs before service clubs. Playlets have been popular and one committee has even produced a song and dance act which has filled a number of engagements to date for such clubs as the Kiwanis, Realtors Association, Shriners, and Breakfast Club, in one of the larger cities. Other committees have been called on to provide speakers for electrical cooking demonstrations for both small and large groups. On solicitation committees have provided models for style shows. Radio music has been

supplied by qualified members. The work of decorating company floats for civic parades has been assigned to the women's organization and in some cases a number of costumed young girls from the committees have formed the central theme of the float. One rather novel service was when a member posed for advertising material in connection with a waffle iron campaign.

Progress of Essay Contest

At present our interest is focused on the Essay Contest in which the women are actively taking part. "Pleasing Mr. and Mrs. Public" is the subject, and it is hoped will result in tangible evidence of the interest of our women employees in serving the Public well. This contest closed May 1.

Conclusion

At the close of the association year 1929, there are twelve working committees representing approximately one thousand women employees.

Progress is being steadily made in the development of the women themselves, in fitting them for larger opportunities to serve, as well as in the clearer concept they are gaining of the functions of the electrical industry and its responsibility of continually improving service to the public.

General Committee Reports

EDUCATIONAL COMMITTEE*

ENROLLMENT in N.E.L.A. educational courses in the Northwest geographic division in the twelve-month period ending Feb. 28, 1929, as compared to the enrollment for the previous twelve-month period was as follows:

	1929	1928
Practical electricity	34	1
Elementary accounting	7	1
Advanced accounting	11	1
Lighting sales	3	11
Merchandise sales	9	0
Power sales	1	7
Electrical metermen	9	--
Not recorded	--	7
Total	74	28

The current year's enrollments were divided among companies as follows:

Northwestern Electric Company	20
Idaho Power Company	19
Eastern Oregon Light & Power Company	16
Utah Power & Light Company	8
Pacific Power & Light Company	4
Public Utilities Consolidated Corporation	2
Kootenay Power Company	1
Mountain States Power Company	1
Portland Electric Power Company	1
Puget Sound Power & Light Company	1
Yamhill Electric Company	1
Total	74

These figures indicate a greater and more widespread interest in the courses during the current year. Further, the returns for March, 1929, with 20 enrollments, indicate that this interest is not lagging.

The addition during the year of the course for electrical metermen which was made available about Jan. 1, 1929, proved to be a welcome step in this division, there being nine enrollments in it during the two months reported above, and ten in the first month of the new report year. The meter committee of the Engineering Section has brought this course to the attention of metermen in this territory, pointing out that the absence of a short course for metermen in this division such as is provided in some other divisions, makes this new N.E.L.A. course the best instruction available in the Northwest for workers in this branch of the business.

Another change in the courses effected during the year just closed was a revision in the advanced accounting course. In this revision the course was shortened somewhat and its price reduced from $40 to $35.

The chairman of the committee and each of the company representatives on it have on hand printed circulars descriptive of each of the courses offered, which they will be glad to send to any enquirer.

The use of company bulletins and magazines was again used to good advantage in bringing before the employees of member companies the nature of the courses offered, and this practice should be continued from time to time.

* **Berkeley Snow,** Electrical West, chairman. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Idaho Power Company:** E. C. Kiersted. **Mountain States Power Company:** John H. N. Adams. **Northwestern Electric Company:** R. W. Faville. **Pacific Power & Light Company:** Geo. T. Bragg. **Portland Electric Power Company:** Geo. Sullivan. **Puget Sound Power & Light Company:** Col. H. G. Winsor. **Utah Power & Light Company:** M. L. Cummings, Jr. **The Washington Water Power Company:** W. H. Ude.